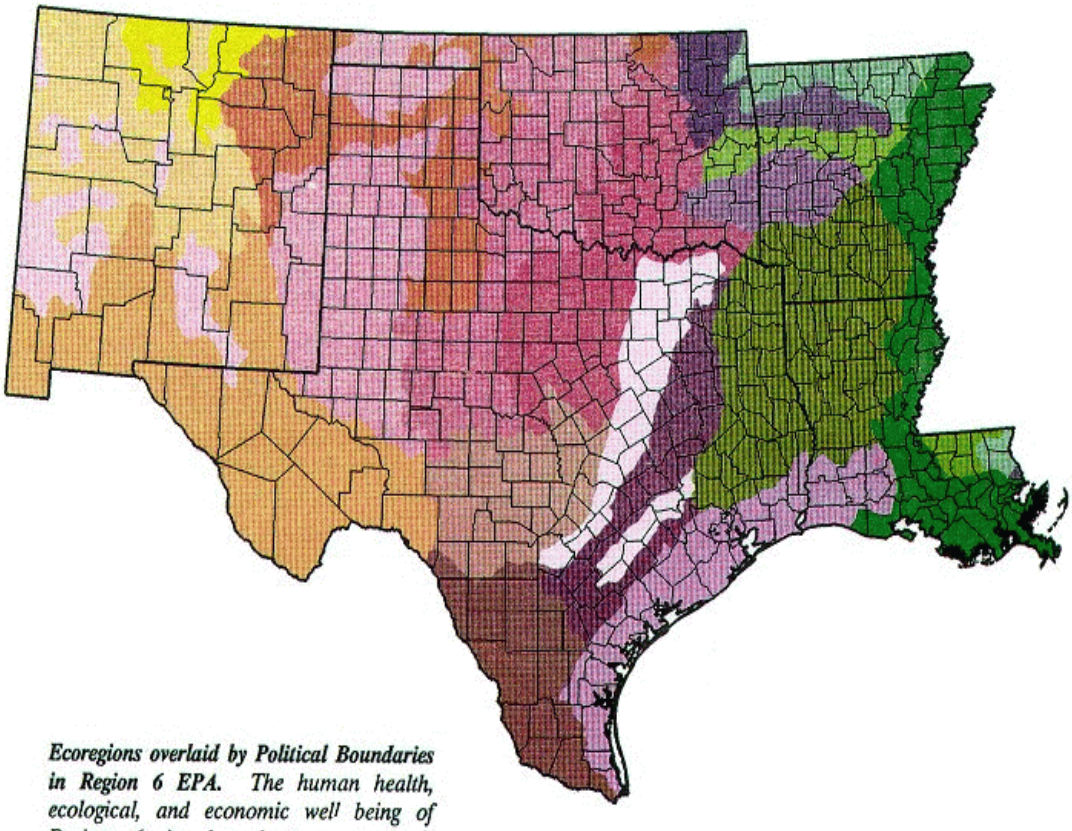
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

OFFICE of PLANNING and ANALYSIS
REGION 6 DALLAS, TEXAS
NOVEMBER, 1990

Region 6 Comparative Risk Project

OVERVIEW REPORT



Ecoregions overlaid by Political Boundaries in Region 6 EPA. *The human health, ecological, and economic well being of Region 6 is dependent upon man's relationship to the environment. All ecological threats are ultimately threats to human health.*

REGION 6 U. S. ENVIRONMENTAL PROTECTION AGENCY

OVERVIEW REPORT:

Regional Comparative Risk Project

November, 1990

Office of Planning and Analysis
Region 6 U. S. EPA
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Comparative risk studies are designed as tools for the prioritization of environmental problems. The ranking process is essential to the effective use of Agency resources and to the understanding of regional issues.

Although these studies utilize basic risk assessment methodologies, the data available to Region 6 scientists was not adequate to perform traditional risk assessments. The results indicating "estimated cancer cases" and "at risk" populations do not represent actual incidence of disease or documented exposures. It was necessary to estimate these parameters in quantitative terms to perform relative rankings.

Through the Comparative Risk Project, Region 6 has gained significant insight into the twenty-four environmental problem areas evaluated. Better resource utilization, more effective cross-media communication, and a greater understanding of environmental problem management are only a few of the many significant results we have realized.

November 30, 1990

MEMORANDUM

SUBJECT: Region 6 Comparative Risk Project Report

FROM: Joe D. Winkle Deputy Regional Administrator (6D)

TO: Hank Habicht Deputy Administrator

The enclosed documents present relative risk rankings of twenty-four environmental problem areas for Region 6. The reports characterize risk to Regional ecology, human health and economy, as well as an evaluation of risk management factors. The reports represent months of methodology development, data gathering, and cross media analysis. Regional scientist strived to write the reports for both government and general audiences.

The Comparative Risk Project offered Region 6 an opportunity to perform evaluations of environmental problems, Regional programs and data systems. This enabled the Region to cross train staff and allowed program scientists to directly participate in multi-media environmental decision making.

Comparative risk projects are not considered classical science endeavors. Staff members contributing to the reports were well aware of the lack of data quality, many data gaps, and the uncertainties associated with each problem area. The results estimating cancer cases and at risk populations do not represent actual incidence of disease or documented exposures. Credibility for such studies can only occur through careful documentation of scientific assumptions and uncertainties.

Staff scientists are confident in their chosen methodologies, but realize that this report was the first attempt to quantitatively characterize risk in Region 6. The Region is anxious to apply comparative risk findings in the strategic planning process.

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EXECUTIVE SUMMARY

The 1987 Environmental Protection Agency (EPA) report entitled Unfinished Business: A Comparative Assessment of Environmental Problems allowed the Agency to evaluate environmental problems and rank them as to risk posed to our nation's ecology and human health. EPA took a courageous look at its allocations of resources and found that environmental problems judged to present the most risk were not always problems that received the most resources or public concern.

Region 6 EPA completed a Regional Comparative Risk Project (RCRP) in November 1990. The Region gathered data for twenty-four environmental problems, developed risk assessment methodologies, and ranked the defined problems. Regional resource data was also assembled. The results of the project are presented in five documents: the Overview, Ecology, Human Health, Risk Management, and Economic reports. The comparative risk results have become the logic behind the Region's strategic planning process.

The Regional risk project suggests, like the national Unfinished Business report, that the greatest risks to the largest ecological areas and number of people in the Region's five States are generally in programs which receive less public attention and EPA resources.

The Ecology Risk report identified Physical Degradation of Terrestrial Ecosystems, Pesticide Application, Physical Degradation of Water and Wetlands, Global Warming, and Stratospheric Ozone Depletion as the Region's highest risk problem areas. Environmental problems in the lowest risk category included Superfund Hazardous Waste Sites (CERCLA), Particulate Matter (PM_{10}), Airborne Lead, and Storage Tanks. The risk presented by each problem was evaluated at the ecoregion level (Region 6 has twenty-three ecoregions represented in the five states) by considering Area of Impact, Degree of Impact, and Degree of Vulnerability for each problem. Criteria was developed to judge each parameter and a computer assisted, mathematical risk formula produced quantitative Ecological Risk Index (ERI) values.

The Human Health report judged Pesticides, Indoor Radon, Indoor Air Pollution, Ozone/Carbon Monoxide, and Stratospheric Ozone Depletion as problems presenting the highest health risks to Region 6. Drinking Water, Hazardous/Toxic Air Pollution, Airborne Lead, and Radiation other than Radon were placed in the moderate-high risk category. Problems ranked in the moderate-low or lowest risk groups included Superfund sites, Municipal and Industrial Wastewater Discharges, Particulate Matter, Groundwater Contamination, Municipal and Industrial Solid Waste sites.

The highest ranked problems identified by the economic risk assessment were the global issues of Stratospheric Ozone Depletion, Global Warming, and Ozone/Carbon Monoxide pollution.

Analysis of Regional resources information shows that 4.7 percent of the Region's cost of full time employees and contract/grant dollars are committed to ecological problems ranked as high and moderate-high risk. Seven percent is committed to the human health problems ranked in

these top two categories. The percentage of resources which are committed to resolving the Region's combined ecological and human health problems in the high and moderate-high risk categories is 9.8 percent. Ninety percent of the Region's resources are utilized to address problems in the moderate-low to lowest risk categories.

Several of the environmental problems ranked in the highest risk categories may not require substantial increases in resources. Opportunities for reduction in human health risks from radon exposure and indoor air pollution can take the form of monitoring of home contaminant levels, public awareness, and educational programs. However, environmental problems such as pesticides application, global warming, hazardous air toxics, stratospheric ozone depletion, and ozone and carbon monoxide pollution may require substantial resource increases and actual life style changes by Region 6 residents. It is also important to realize that reallocation of EPA resources will not necessarily reduce risk proportionally without concurrent commitment to changes in existing laws. For example, many activities that physically degrade wetlands and terrestrial ecosystems are not regulated or are weakly regulated by EPA.

Human activities resulting in the physical degradation of water, wetlands, and terrestrial ecosystems include urbanization, conversion of wetlands to agriculture, mining, silviculture, and depletion of valuable ground water reservoirs. Resolution of these problems will require a coordinated effort from local, State, and Federal agencies, as well as significant public attention and awareness.

The Science Advisory Board (SAB) was asked by William Reilly, Administrator, U.S. Environmental Protection Agency, to review the findings of the Unfinished Business report. The board basically agreed with the documents rankings and offered several suggestions for EPA. The suggestions were:

1. EPA should target its environmental protection efforts on the basis of opportunities for the greatest risk reduction.

2. EPA should attach as much importance to reducing ecological risk as it does to reducing human health risk.

3. EPA should improve the data and analytical methodologies that support the assessment, comparison, and reduction of different environmental risks.

4. EPA should reflect risk-based priorities in its strategic planning processes.

5. EPA should reflect risk-based priorities in its budget process.

6. EPA, and the nation as a whole, should make greater use of all the tools available to reduce risk.

7. EPA should emphasize pollution prevention as the preferred option for reducing risk.

8. EPA should increase its efforts to integrate environmental considerations into broad@r aspects

of public policy in as fundamental a manner as are economic concerns.

9. EPA should work to improve public understanding of environmental risks and train a professional workforce to help reduce them.

10. EPA should develop improved methods to value natural resources and to account for long-term environmental effects in its economic analyses.

The human health, ecological, and economic well being of Region 6 is dependent upon a stable environment. All ecological threats are ultimately threats to human health and the economy. The Region 6 Comparative Risk Project results and conclusions underscore this direct relationship between the environment and man's activities and support the recommendations of the Science Advisory Board.

Comparative risk analyses should be written for all audiences. A universal understanding of environmental risk is necessary for the most efficient management of environmental protection resources. Therefore, Region 6 welcomes all opportunities to communicate the results and interpretations of this comparative risk study.

I. INTRODUCTION

Environmental risks which continue to persist despite existing state and federal programs are labeled "residual risks". The Environmental Protection Agency's Unfinished Business: A Comparative Assessment of Environmental Problems was an attempt to identify the nation's persistent risks to ecology and human health. It was also EPA's courageous effort to ask itself why these risks remain. A conclusion from the 1987 report was that the Agency's resources have been directed to address the public's perception of risk and not EPA's assessment of the most serious environmental problems.

Each of EPA's ten Regions was asked to perform comparative risk analyses specific for the states within their jurisdiction. The primary mission of Region 6 Comparative Risk Project (RCRP) was to gather scientific data and regulatory information for the purpose of evaluating twenty-four environmental problem areas as to their relative risk to the Region's ecology, human health, and economy.

The results of the rankings would be the logic behind the Region's strategic planning process. Therefore, the Region would develop a risk based approach to identifying and addressing environmental problems.

Scientists in Region 6 performed the ecological, human health, and risk management comparative evaluations using EPA staff. An economic risk evaluation was performed by Industrial Economics, Incorporated (IEc), Cambridge, MA., who was contracted to provide technical and report writing assistance for the economic analysis.

Region 6

Region 6 includes the states of Arkansas, New Mexico, Oklahoma, Louisiana, and Texas. These states vary considerably in ecological, demographic, economic, and political character.

The Region has densely populated areas inland and on the coast. There are also many sparsely populated inland areas. The ecology contains twenty-three different ecoregions including coastal estuaries, inland marshes, river alluvial plains, forest areas, prairies, hill country, desert, and mountains. The economy of Region 6 is based on commercial industries like oil and gas, chemical manufacturing, agriculture, mining, commercial fishing, and silviculture. The environmental risks posed by twenty-four problem areas were matched to this demographic, ecological, and economic mosaic that is Region 6.

Problem Areas

Twenty-four environmental problem areas were selected from a core list of problems suggested by the Office of Policy and Planning at Headquarters EPA. The environmental problem areas were:

Industrial Wastewater Discharges to Oceans, Lakes, and Rivers
Municipal Wastewater Discharges to Oceans, Lakes, and Rivers
Aggregated Public and Private Drinking Water Supplies
Non-Point Source Discharges to Oceans, Lakes, and Rivers
Physical Degradation of Water and Wetland Habitats
Aggregated Ground-Water Contamination
Storage Tanks
RCRA Hazardous Waste
Hazardous Waste Sites --Abandoned/Superfund Sites Municipal Solid Waste Sites
Industrial Solid Waste Sites
Accidental Chemical Releases to the Environment Pesticides
Sulfur Oxides and Nitrogen Oxides (including Acid Deposition) Ozone and Carbon Monoxide
Airborne Lead
Particulate Matter
Hazardous/To)dc Air Pollutants
Indoor Air Pollutants Other Than Radon Indoor Radon
Radiation Other than Radon
Physical Degradation of Terrestrial Ecosystems/Habitats

A number of observations were made concerning the approach to the overall project once the core was established.

It was not possible to define problem areas in a way which would avoid the overlapping of pollution sources or contaminants (i.e., radon exposure from indoor air and volatilization of radon from drinking water).

The list of problem areas unavoidably included regulatory language from EPA programs (i.e., RCRA hazardous waste sites, CERCLA hazardous waste sites, pesticides, municipal waste sites).

Global Warming and Stratospheric Ozone Depletion were evaluated for two reasons:

(1) The problems are caused by emissions to air from sources within Region 6 (i.e., mobile, agricultural, residential, and industrial)..
(2) The problems were believed to present significant future risk.

A need to address Regional specific problem areas such as the oil and gas industry, the Gulf Coast, Louisiana-Mississippi wetlands, and the U.S./Mexico border was recognized. Regional program reports for several problem areas addressed these Regional concerns.

Approach

The Region's Division Directors, Regional Administrator, and Deputy Administrator acted as members of the RCRP Steering Committee. The Steering Committee, the Project Director, and workgroup Chairpersons established key agreements and ground rules. Three categories of risk were identified; risks to the Region's diverse ecology, risks to the health of its over twenty-eight

million residents, and risks to the economy of five states. In addition, the workgroup Chairpersons and Steering Committee decided to evaluate factors critical to managing risks in the Region. Risk management analyzed the subjective components of public perception, legal authority, and available technology. A Risk Management workgroup was charged with gathering program resources data (i.e., number of full time employees (FTE's), program allocations, and grant dollars). The data and the insight gained from analysis of risk management factors were used to formulate a Regional strategic plan.

Only residual risks were addressed, the risks that persist with current levels of control and compliance. Risks that may exist if controls were changed were not considered. This early agreement became very important when the RCRP participants began to examine and compare specific program data. For example, there are decided regulatory and compliance differences among the drinking water, air toxics, CERCLA (Superfund), and wetlands degradation programs.

Workgroups were organized and comparative risk methodologies developed. A request for risk data was delivered to each Region 6 Branch. These data represented the Region's scientific analysis which included EPA program assumptions and uncertainties. The program's risk data was reviewed by workgroups and became the project's "Program Reports". Each workgroup used the program reports and data from other sources (states, academia, federal agencies) to evaluate each problem area.

Methods

The Ecological workgroup did not have established guidelines for the evaluation of risks. The workgroup members decided upon a ecoregion approach, identified critical ecological functions, and developed a risk index formula. This novel approach resulted in a method to assess risk which is reproducible, well documented, and computer based (data integratable). Data was reviewed for area of impact, degree of impact, and vulnerability (endangered species, soil erosion rates, stream density, etc.).

After data input, ecological risk index values were generated for each problem area per ecoregion in the five state area. The Region's Geographic Information System (GIS) was used to display ecological risk data.

The Human Health workgroup evaluated the carcinogenic and non-carcinogenic risk posed by the twenty-four environmental problem areas. Workgroup members relied upon the program reports as well as national and state data. There was very little Regional data for several problem areas (i.e., ground water contamination, storage tanks, municipal and industrial waste sites). Standard components of EPA's risk assessment methodology were used.

The cancer evaluation methodology involved three steps: 1) A short list of chemicals was identified which were representative of emissions for individual problem areas. 2) Cancer potency factors (Po were utilized. 3) Exposure evaluation included estimates of chemical concentrations, resulting doses, and the likely populations exposed. Upper bound risk was calculated.

Non-cancer methods used EPA reference dose (RfD) evaluations and the determinations of chemical end points. Where ambient pollutant data was available, hazard index calculations were performed. Estimates of populations impacted or "at risk" were determined from regulatory data.

Degrees of uncertainty were determined for each human health problem and described as high, medium, or low. The criteria for these evaluations were: 1) animal toxicity data, 2) epidemiology data, 3) ambient and/or biological monitoring data, 4) medical or regulatory case study information, 5) number of chemicals with adequate data, and 6) the degree of extrapolation performed.

The economic evaluation and relative ranking was performed by Industrial Economics, Inc. (IEc). The economic/welfare damages evaluated for each problem area included health care costs and lost wages, damages to commercial harvests of fish, crops, and timber; natural resource damages, damages to materials in use; reductions in recreational opportunities; remediation damages; and aesthetic damages.

Report Organization

This overview document presents summary information from four Region 6 comparative risk reports.

Appendix A: Ecological Report
Appendix B: Human Health Report
Appendix C: Risk Management and Economic Report
Appendix D: Program Reports

The presentations of methodologies, summary of results, and observations and comments are taken from the individual appendices listed above. References are listed for each appendix.

Attachment A of this overview document defines the environmental problems ranked. Attachment B is a glossary of terms for both Ecological and Human Health reports. A historical review of risk ranking for Unfinished Business and, those for Regions 1, 3, and 10 is presented in Attachment C. Attachment D is a collection of important comparative risk articles, explaining the Agency's perspective and goals for comparative risk and strategic planning. The final attachment, Attachment E, is a summary of human health risk evaluations for each problem area.

Region 6 Risk Rankings

The Ecological, Human Health, and Economic Workgroups categorized the problem areas into four groups. Category 1 representing the highest risk and Category 4 the lowest risk. The cancer and non-cancer Human Health rankings were combined. The Region 6 Comparative Risk Rankings are presented on page 5. The problem areas were not ranked within each category. The Region's rankings and a brief discussion for each risk evaluation is presented in the "Region 6 Rankings of Problem Areas and Summary Comments" section beginning on page 9.

REGION 6 COMPARATIVE RISK RANKINGS

ECOLOGICAL	HUMAN HEALTH	ECONOMIC
Highest Risk	*Highest Risk*	*Highest Risk*
Physical Degradation of Terrestrial Ecosystems	Pesticides	Global Warming
Pesticide Application	Indoor Radon	Stratospheric Ozone Depletion
Physical Degradation of Water and wetlands	Indoor Air Pollution	Ozone/Carbon Monoxide
Global Warming *	Ozone/Carbon Monoxide	Indoor Radon
Stratospheric Ozone Depletion*	Stratospheric Ozone Depletion	Indoor Air Pollution
Non-Point Source Discharges to Water	Drinking Water	Physical Degradation of Water and Wetlands
Hazardous/Toxic Air Pollution	Hazardous/Toxic Air Pollution	Non-Point Source Discharges to Water
Ozone/Carbon Monoxide	Airborne Lead	Particulate Matter (PM_{10})
Municipal Wastewater Discharges	Radiation other than Radon	$S0_2$ /NO_X
Hazardous Waste Sites RCRA	Superfund Hazardous Waste Sites CERCLA	Industrial Wastewater Discharges
Industrial Wastewater Discharges	Municipal Wastewater Discharges	Municipal Wastewater Discharges
Groundwater Contamination	Industrial Wastewater Discharges	Hazardous/Toxic Air Pollution
Municipal Solid Waste Sites	$S0_2$ /NO_X	Drinking Water
Industrial Solid Waste Sites	Storage Tanks	Groundwater Contamination
Accidental Releases	Particulate Matter (PM_{10})	Pesticides
Lowest Risk	Accidental Releases	Oil Production/ Storage/Transportation
Superfund Hazardous Waste Sites CERCLA	Groundwater Contamination	*Lowest Risk*
Particulate Matter (PM_{10})	Hazardous Waste Sites RCRA	Storage Tanks
Airborne Lead	Non-Point Source Discharges to Water	Hazardous Waste Sites RCRA
Storage Tanks	*Lowest Risk*	Superfund Hazardous Waste Sites CERCLA
Not Ranked:	Municipal Solid Waste Sites	Municipal Solid Waste Sites
Drinking water, indoor Radon, Indoor Air Pollution, Radiation other than Radon, $S0_2$ /NO_X	Industrial Solid Waste Sites	Accidental Releases
*see discussion	*Not Ranked:*	Radiation other than Radon
	Physical Degradation of Water and Wetlands, Terrestrial Ecosystems, Global Warming.	Airborne Lead
		Not Ranked:
		Industrial Solid Waste Sites, Physical Degradation of Terrestrial Ecosystems

Regional Perspective: "Reducing Risk", The Science Advisory Board Report

The Science Advisory Board (SAB) was asked by William Reilly, Administrator - U.S. EPA, to review the risk comparisons in the 1987 Unfinished Business study. The Board identified several environmental problem areas which continue to pose significant risk to the nation. Although the problem areas were not defined exactly like those for the EPA projects', and different methodologies were utilized, the overall SAB assessment was consistent with Unfinished Business and other risk evaluations. The board set forth ten recommendations as suggestions or steps that the Environmental Protection Agency should follow to improve efforts by the Agency, Congress, and the entire country, to reduce environmental risks (U.S. EPA, 1990). The comments following are a Regional perspective of the SAB recommendations.

The first recommendation was that **EPA target its protection efforts (resources) on the basis of opportunities for the greatest risk reduction.** The Region 6 Human Health comparative risk results have placed radon, indoor air pollution, ozone/carbon monoxide, and stratospheric ozone depletion in the highest risk category. Opportunities for protection of human health from these problems range from the quite direct and simple to drastic changes in regional lifestyles. Risks from radon and indoor air pollution can potentially be reduced by public awareness and education programs. Homes can easily be tested for radon levels. Residents can then make personal choices concerning this public health issue. Awareness of the sources of air pollution within homes and some simple preventive actions can eliminate or greatly reduce chemical exposures (i.e., proper storage and use of solvents, paints, and pesticides). Indoor air pollution and radon may only require a small investment by EPA to produce significant risk reductions.

Ozone/Carbon Monoxide, Pesticides, and Stratospheric Ozone Depletion problem areas may require significant resource investments in addition to public awareness and education. Lifestyle and economic adjustments required for resolution of these problem areas could include continued curtailment of agricultural and residential use of persistent pesticides, sustainable agriculture, reducing miles traveled by the driving public, acceptance of alternatives for halogenated refrigerants, de-greasers, and processes for foam and plastics manufacture. Targeting on the basis of comparative risk can begin now that these Regional human health risks are identified.

The Ecological workgroup placed Physical Degradation of Terrestrial Ecosystems, Physical Degradation of Water and Wetland, Pesticides Application, and the global issues of Stratospheric Ozone Depletion and Global Warming in the highest risk category. Resources toward these problems can certainly take the form of public and intra-agency awareness activities. All EPA employees are in need of educational programs which define and explain basic concepts such as loss of biological diversity, climatic control factors, sustainable agriculture, and ecologically directed urbanization. Region 6 should begin such programs.

Several of the other suggestions made by the board can be incorporated into a discussion of the Region's high risk problem areas. The suggestion that **EPA reflect risk based priorities in our long range plans and budget process** is being addressed through the Agency's strategic planning initiatives. The "logic" for Regional strategic plans reside in comparative risk. The opportunity for EPA to **improve public understanding** can certainly be offered through public

awareness programs for specific problems (i.e., radon, indoor air pollution, global issues) and an effort to publicize comparative risk findings and strategic plans.

Suggestions to **improve the scientific data quality and develop risk methodologies** were well received by the workgroups. Recognition of specific data gaps was a very important outcome of the study. Realization that data required for risk analyses was often within other federal agencies or governments has allowed EPA to begin the process of **data integration with other agencies** (i.e., agriculture data from the Soil Conservation Service, hazardous waste information from environmental agencies in Mexico).

Perhaps the most significant recommendation was for **EPA to attach as much importance to reducing ecological risk as it does to reducing human health risk.** Although the Human Health workgroup certainly focused on populations at risk, political boundaries, and diseases specific to the human species, they recognized that specific problem areas may present as much or more of an ecological threat than a human health concern. Hazardous Air Pollutants (global warming) and Stratospheric Ozone Depletion are two such problem areas.

All ecological threats are ultimately threats to human health. Man depends upon **a** predictable global ecology for air quality, water, food, shelter, and medicines. Ecological problems such as loss of terrestrial and wetland habitats result in species extinction and overall loss of biological diversity. Humans depend upon a diverse plant and animal gene pool for food production. If genetic diversity is diminished, adaption to changing environments will decrease as will resistance to diseases, pests, and the elements. The end result will be fewer and less productive varieties of food and fiber crops. The net effect of decreasing diversity in ecosystems is an unstable system (Menzer and Nelson, 1986).

Ecological problems in Region 6 with far reaching human health and economic impacts include threatened elimination of an underground water supply in the High Plains ecoregion (Ogallala Aquifer), elimination of wetlands in Louisiana, and the additive discharges of chemicals to surface water from agriculture (nitrogen, phosphates, pesticides, and animal waste), industrial discharges (organic and non-organics), and urban runoff (organics, sewage, pesticides). These human ecology issues were not adequately addressed by either the Ecological or Human Health workgroups. Region 6 has begun a review of the 1990 RCRP findings with an emphasis upon human ecology.

This area of ecological study is very important. Although humans are one species among thousands, they are the only species that can chemically and biologically alter the planet. Human activity has changed the course of evolution through agricultural and industrial technology, we must begin to understand that, ecologically, humans have a responsibility to preserve the earth's life if but to protect human life. We have not demonstrated the knowledge, wisdom, or compassion to accept this role.

EPA scientist should make human health professionals aware of ecology based impacts. Physicians and toxicologist must understand that the traditional dose response relationship, central to human toxicology, may not serve to quantify long term health impacts from loss of

biological diversity or ecological habitat destruction. Human ecology should be defined and addressed in future comparative risk studies.

Discussion

Comparative risk studies are tools for the prioritization of environmental problems. The ranking process is essential to the effective use of Agency resources and to the understanding of regional issues.

Although these studies utilize basic risk assessment methodologies, the data was not adequate to perform traditional risk assessments. Results indicating 'estimated cancer cases" and "at risk" populations do not represent actual incidence of disease or documented exposures. It was necessary to estimate these parameters in quantitative terms to perform relative rankings.

Through the Comparative Risk Project, Region 6 has gained significant insight into the twenty--four environmental problem areas evaluated. Better resource utilization, more effective cross-media communication, and a greater understanding of environmental problem management are only a few of the many significant results realized.

The Regional Comparative Risk Project suggests, like the national Unfinished Business report, that the greatest risks to the largest ecological areas and number of people in the Region's five states are generally in programs receiving a disproportionate level of public attention and EPA resources. Comparative risk analysis should be written for all audiences, realizing that more efficient management of resources is dependent upon a universal understanding of environmental risk. The Region welcomes all opportunities to communicate the reports findings and share in the development of future comparative risk projects.

Region 6 Ranking of Problem Areas and Summary Comments

Risk Area	Ranking	Summary Comments
INDUSTRIAL DISCHARGE TO WATER Problem No. 1		
Ecological Risk	Moderate-Low	Areas of impact are those stream segments in each ecoregion that are not meeting water quality standards due, at least in part, to industrial point source discharges. The ecoregions with the highest risk index values are those with the greatest percentage of stream miles impaired by industrial point source discharges.
Human Health Risk	Moderate-Low	Chemicals: 2,3,7,8-Tetrachlorodibenzo-p-dioxin (Dioxin) Hexachlorobenzene, Mercury. Exposure/Toxicity: Cancer Risk - Only two chemicals reviewed (dioxin and hexachlorobenzene). Estimated number of annual cancer victims was 11. They re due almost entirely to dioxin. Non-Cancer Risk -Only one chemical reviewed mercury). No exceedances of the reference dose (RfD) were calculated. Uncertainty: High - Only 3 chemicals were evaluated. There is limited fish tissue data for toxic chemicals in fish.
Economic Risk	Moderate-Low	Annual economic damages: $4 million to $26 million. Most of these damages re attributed to recreational losses. The range is due to uncertainty about the percent of freshwater and saltwater resources not meeting fishable/swimmable goals.

Region 6 Ranking of Problem Areas and Summary Comments

Risk Area	Ranking	Summary Comments
MUNICIPAL DISCHARGE TO SURFACE WATER Problem No. 2		
Ecological Risk	Moderate-Low	Areas of impact are those stream segments in each ecoregion that are not meeting water quality standards due, at least in part, to POTW discharges to surface water. The ecoregions with the highest risk index values are those with he greatest percentage of stream miles impaired by POTW discharges. The western Gulf Coastal Plains, the Mississippi Alluvial Plains, the Southeastern Plains and Central Irregular Plains of Oklahoma have the highest risk index values.
Human Health Risk	Moderate-Low	Chemicals: Chlorobenzenes, Methylene, Chlorides, Tetrachloroethylene, Arsenic, Mercury, Chromium, Selenium, Nickel, Cadmium, fecal bacteria. Exposure/toxicity: Cancer Risk - Four carcinogens were addressed Chlorobenzenes, Methylene Chloride, Tetrachloroethylene and Arsenic. The estimated number of annual cancer cases was 19, with arsenic being the largest contributor. Non-Cancer Risk - Six non-carcinogens were addressed: Mercury, Chromium, Selenium, Nickel, Cadmium, and fecal bacteria. Of these only mercury exceeded the Reference Dose (RfD). Uncertainty: High - The data does not represent the entire set of chemicals posing a bioaccumulative challenge in R6.
Economic Risk	Moderate-Low	Annual economic damages $28 million to $77 million. Most damages attributable to recreational losses with relatively small amounts attributable to health damages and commercial harvest losses. Uncertainty concerning the percent of fresh and alt water resources not meeting fishable/swimmable goals.

Region 6 Ranking of Problem Areas and Summary Comments

Risk Area	Ranking	Summary Comments
DRINKING WATER (PUBLIC AND PRIVATE) Problem No. 3		
Ecological Risk	N/A	
Human Health Risk	Moderate-High	Chemicals: Fluoride, Benzene, Ethylbenzene, Toluene, Xylene(s) Lead, Arsenic, Barium, Selenium, Radon, BOCs, Nitrate, THMs, cis - 1,2 Dichloroetyhylene, Dichlorodifluoromethane, Tetrachloroethylene, Trichloroethylene, Combined Radium, Coliform. Exposure/Toxicity: Cancer Risk - Estimated annual cancer incidence for TTHM, and Radium, VOC and Radon is 199 in R6. A large portion is due to radon exposure. 4.6 million R6 residents may be exposed to unsafe levels of 10 carcinogens reviewed. Non-Cancer Risk - 4,200,000 R6 residents may be exposed to drinking water and 2.7 million could be exposed to microbiological contaminations. Entire R6 population is potentially exposed to drinking water contaminants. Uncertainty: Moderate-good animal and epidemiology data for selected chemicals, limited population exposure data, suspected under reporting of disease incidence.
Economic Risk	Moderate-Low	Annual economic damages $18 million to $30 million. Health damages due to cancer account for about $13 million and resource damages to groundwater wells account for about $5 million to $18 million. Additional health damages could be due to non-carcinogenic health effects.

Region 6 Ranking of Problem Areas and Summary Comments

Risk Area	Ranking	Summary Comments
NON-POINT SOURCE DISCHARGES TO WATER Problem No. 4		
Ecological Risk	Moderate-High	Areas of impact include those stream segments in each ecoregion that are not meeting water quality standards due, at least in part, to non-point source problems. Ecoregions with the highest risk index values are not those with the greatest percentage of stream miles impacted. The ecoregions with greatest risk index values are the Southern Rockies and Arizona/New Mexico Plateau. The ranking is due not only to percentages of stream miles impacted but also due to vulnerability of the ecoregions.
Human Health Risk	Moderate-Low	Chemicals: Chlordane, Dieldrin, PCBs, Endrin. Exposure/Toxicity: The chemicals assessed were chlordane, dieldrin, and PCBs. There was an estimated risk of 70 additional cases. This number was due mainly PCBs with an estimate of 59 additional cancer cases. Non-Cancer Risk mainly endrin was reviewed for Louisiana and was found to be insignificant. The their states were expected to show the same result. Uncertainty: High - limited fish tissue data for toxic chemicals from non-point sources.
Economic Risk	Moderate-High	Annual Economic Damages: $73 million to $290 million. Most of the damages re attributable to recreational losses with a few million dollars in damages attributable to health damages and commercial harvest losses. The range is due primarily to uncertainty about the percent of freshwater and saltwater resources not meeting fishable/swimmable goals.

Region 6 Ranking of Problem Areas and Summary Comments

Risk Area	Ranking	Summary Comments
PHYSICAL DEGRADATION OF WATER AND WETLANDS Problem No. 5		
Ecological Risk	High	Area of impact is the estimated remaining acreage of wetlands per ecoregion. In some cases it is not possible to locate information on an ecoregion basis. Excluding those regions, the ecoregions with the greatest risk index values are he Western Gulf Coastal Plain and Mississippi Alluvial Plains.
Human Health Risk	N/A	
Economic Risk	Moderate-High	Total annual economic damages range from about $92 million to $502 million. These resource damages include losses attributable to commercial fisheries and timber harvests, recreational fishing and hunting, and storm and flood protection. Wetlands also provide some other values, such as enhancement of water quality, that Industrial Economics, Incorporated was unable to quantify. The range is due primarily to uncertainty over the value of certain wetland functions and the basis of extrapolating those values to the quantity of resources lost annually.

Region 6 Ranking of Problem Areas and Summary Comments

Risk Area	Ranking	Summary Comments
AGGREGATE GROUND WATER Problem No. 6		
Ecological Risk	Moderate-Low	Problem not evaluated using the risk index methodology.
Human Health Risk	Moderate-Low	Chemicals: Nitrate, Fluoride, Benzene, Arsenic, Ethyl Benzene, Toluene, Radon, (VOC'S) Barium, Selenium, Radium, Trichloroethylene. Exposure/Toxicity: Cancer Risk - Radon is estimated to be the largest source of cancer incidents originating from ground water sources in R6. Radon is estimated to account for 60 cancer cases annually. Other carcinogens in drinking water from ground water are estimated to result in I additional case. Noncancer Risk - An estimated 439,100 people may be exposed to unsafe levels of non-carcinogens from ground water. Ile 3,400,000 persons who depend on unregulated private domestic wells in R6 are probably exposed to much greater levels of contaminants in their drinking water than are PWS customers. Uncertainty: Moderate - good animal and epidemiology data for selected chemicals, limited population exposure data.
Economic Risk	Moderate-Low	Annual Economic Damages: $18 million to $30 million. Health damages due to cancers account for about $12 million and resource damages to ground water wells account for about $5 million to $18 million. Additional health damages would be due to non-carcinogenic illnesses, which was unaccounted for in this analysis.

Region 6 Ranking of Problem Areas and Summary Comments

Risk Area	Ranking	Summary Comments
UNDERGROUND STORAGE TANKS Problem No. 7		
Ecological Risk	Low	Problem not evaluated using the risk index methodology.
Human Health Risk	Moderate-Low	Chemicals: Primary constituents of gasoline and petroleum products. Exposure/Toxicity: Cancer Risk - The R6 data indicates a moderate risk. Non cancer Risk - The non-cancer risk is estimated to be less than the cancer risk because of small percent of the population affected (<l%). Health exposures 11 result from regions coming in contact with contaminated soil or water. Uncertainty: High- Accurate data difficult to collect for large number of leaking tanks, the number of drinking water wells affected by a leak, and the number of people affected by a drinking water well.
Economic Risk	Low	Annual Economic Damages: $0.5 million to $1 million. Most of the quantifiable damage was due to replacement of contaminated wells. Health damages due to cancer account for a negligible amount and incidence of other diseases was unavailable for quantification purposes.

Region 6 Ranking of Problem Areas and Summary Comments

Risk Area	Ranking	Summary Comments
HAZARDOUS WASTE SITE (RCRA) Problem No. 8		
Ecological Risk	Moderate-Low	The ecoregions with the greatest number of facilities have the greatest risk index values. The Western Gulf Coastal Plains (with 1/3 of all RCRA facilities) the Texas Blackland Prairies, the Central Irregular Plains and the Mississippi Valley Loess Plain all ranked high due to the large number of facilities.
Human Health Risk	Moderate-Low	Chemicals: Polychlorinated Biphenyls, Trichloroethylene, Benzene, Polynuclear aromatic Hydrocarbons, Cadmium, Chromium, Dichlorobenzene, Chlorobenzene, Arsenic, Chlorinated Solvents. Exposure/Toxicity: Cancer Risk - 700,000 people live within a 1-mile radius of the RCRA facilities in R6. This is the "at risk" population. The individual risk m RCRA facilities was estimated to be $3x10^{-3}$ excess cancer incidents. That is 100 excess lifetime incidents or 30 incidents per year. Non-Cancer Risk -The chronic non-cancer risk is assumed to be insignificant. Uncertainty: Moderate - due to lack of concentration data available for the documented releases and the extrapolation of data from 40 sites to an estimated facilities in R6.
Economic Risk	Low	Annual Economic Damages: Approximately $2 million. Health damages due to cancers account for all the economic damage in this problem area and minimal k of other diseases. There may be some damages due to replacement of contaminated wells, but data is unavailable to measure this loss.

Region 6 Ranking of Problem Areas and Summary Comments

Risk Area	Ranking	Summary Comments
ABANDONED HAZARDOUS WASTE (Superfund) Problem No. 9		
Ecological Risk	Moderate-Low	The risk information reflects risk index values for fourteen ecoregions which contain at least one CERCLA site. Information was provided by the program n actual size of each site plus an estimated off-site zone on impact of one mile in radius around each facility. Those ecoregions with the highest risk index values were those with the greatest percentage of ecoregion impacted.
Human Health Risk	Moderate-Low	Chemicals: Polychlorinated Biphenlyls, Hexachlorobutadiene, Chromium, Arsenic, Pentachlorophenol, Polynuclear Aromatics, Hydrocarbons, 2,3,7,8 trichlorodibenzo - p - Dioxin, Cadmium, Benzene, Trichloroethylene. Exposure/toxicity: Cancer Risk: The estimate of the cancer risks from Superfund sites in R6 was based on the 22 baseline risk assessments reviewed for he problem area. Populations within a 1 mile radius of these 22 sites ranged m 71,000 to 500 people, with an average of 5,000 people. 5,000 people are at risk" at each current and potential superfund site in R6. It was estimated that 3,950 excess cancer incidents over 70 years, or 55 incidents per year may be due to exposure to unremediated superfund sites in R6. Non-Cancer Risk They were assumed not to be significant. Uncertainty: Moderate - good toxicity and some epidemiology data for individual chemicals. Uncertainty due largely to extrapolation of risk and population from he 22 risk assessments reviewed to the total number of sites to be addressed in Superfund.
Economic Risk	Low	Annual Economic Damages: Approximately $4 million. Health damages due to cancers account for about $3 million, and resource damages measured by placement of contaminated wells account for about $1 million.

Region 6 Ranking of Problem Areas and Summary Comments

Risk Area	Ranking	Summary Comments
MUNICIPAL SOLID WASTES Problem No. 10		
Ecological Risk	Low	Not ranked.
Human Health Risk	Low	Chemicals: Vinyl Chloride, Dichloromethane, 1,1,2,2 -Tetrachloroethane, Arsenic, Carbon Tetrachloride. Exposure/Toxicity: Cancer Risk - None. Non-Cancer Risk They were assumed to negligible. Uncertainty: High - There was a lack of available Regional data. It was also due to the extrapolation of national data to Region 6.
Economic Risk	Low	R6 was unable to provide data on health risks or resource damages to ground water connected with municipal waste sites. IEc's ranking is based on the assumption that total annual economic damages are negligible.

Region 6 Ranking of Problem Areas and Summary Comments

Risk Area	Ranking	Summary Comments
INDUSTRIAL WASTES Problem No. 11		
Ecological Risk	N/A	
Human Health Risk	Low	Chemicals: Vinyl Chloride, dichloromethane, 11,2,2,-Tetrachloroethane Exposure/Toxicity: The workgroup considered the cancer and non-cancer risks for this problem to be similar to the risks for Municipal Solid Waste Sites. Virtually no data was available for this problem area in the Region or from the states, regarding releases from facilities and populations impacted by any releases. Uncertainty: High - the lack of data made an estimate of risk difficult.
Economic Risk	N/A	

Region 6 Ranking of Problem Areas and Summary Comments

Risk Area	Ranking	Summary Comments
ACCIDENTAL CHEMICAL RELEASES Problem No. 12		
Ecological Risk	Moderate-Low	This category included any contaminant accidentally released into the environment during transport or production. The distribution of residual risk from accidental releases occurs in most ecoregions within EPA Region 6. Projected impacts based upon a 50-year period. The ecoregions with the highest risk index values were the Mississippi Valley Loess Plain of Louisiana, the Western Gulf Coastal Plain of Texas and the Central Irregular Plains of Oklahoma.
Human Health Risk	Moderate-Low	Chemicals: Hazardous materials under CERCLA and SARA. Exposure/toxicity: Cancer Risk - incidents indeterminate. Virtually no data on exposures or concentrations. Non-Cancer Risk - In R6 in FY89, 43 deaths and 71 injuries were reported as directly resulting from hazardous materials release, almost all were explosive materials. R6 has approximately 115 of the accidental chemical spills reported nationwide. In FY89, 1585 releases of hazardous materials, involving more than 50 million pounds were reported in R6. Uncertainty: Moderate - Exposure and concentration data are nonexistent. Injury data are probably under-reported.
Economic Risk	Low	Annual Economic Damages: $1.4 million to $2.5 million primarily for evacuation damages, IEc restricted its analysis to spills or releases that affect the ambient environment and did not consider industrial accidents. There may be some earth damage associated with acute exposure to spilled substances, but R6 was unable to provide such estimates.

Region 6 Ranking of Problem Areas and Summary Comments

Risk Area	Ranking	Summary Comments
PESTICIDES Problem No. 13		
Ecological Risk	High	The application of pesticides occurs across most ecoregions but it is particularly widespread in the Mississippi Alluvial Plain, Western High Plains, Central Great Plains and Central Irregular Plains of Oklahoma. High percentages of these areas are in agricultural production, consequently they have high risk index values.
Human Health Risk	High	Chemicals: Alachlor, Atrazine, Captan, Chlorothalonil, Chloropyrifos, Diazinon, Dicofal, Malathion, Propoxur, Trifluralin. Exposure/toxicity: Non-Dietary - farm workers, applicators, commercial, residential. Estimated annual cancer cases is > 2,000, estimated Dietary cancer cases is > 300. Non-Dietary/Non-Cancer hazard index values ranged from 0.25 - 2,000 for chemicals reviewed. R6 has a significant farm labor force. Most pesticides have not been adequately characterized as to their toxic potential. Most at risk population is the farm labor force. Uncertainty: Moderate - identified and documented exposure to labor force, animal data, acute toxicity documented.
Economic Risk	Moderate-Low	Annual Economic Damages: $15 million to $373 million. The wide range of damage estimates is due to health damages caused by cancer incidence estimates hat ranged from 177 to 5584 per year.

Region 6 Ranking of Problem Areas and Summary Comments

Risk Area	Ranking	Summary Comments
SULFUR OXIDES AND NITROGEN OXIDES Problem No. 14		
Ecological Risk	No Evidence Provided to Indicate Ecological Risk	
Human Health Risk	Moderate-Low	Chemicals: Sulfur oxide and Nitrogen Oxides. Exposure/Toxicity: R6 population that live in areas that have exceeded SO, standard is 4,049,738. Approximately 10% of this population may be asthma, bronchitis, or emphysema patients. Approximately 400,000 people could be affected, NO. is a major contributor to smog and global warming conditions. Uncertainty: Moderate - good monitoring data, documented respiratory effects, at risk population identified.
Economic Risk	Moderate-High	Annual Economic Damages: $198 million to $587 million. Most are attributable o estimates of visibility degradation calculated by extrapolating contingent valuation studies from eastern cities. Uncaptured in this assessment are any damages to materials caused by acidic deposition in urban areas.

Region 6 Ranking of Problem Areas and Summary Comments

Risk Area	Ranking	Summary Comments
OZONE/CARBON MONOXIDE Problem No. 15		
Ecological Risk	Moderate-Low	These discharges were only considered problems where there were nonattainment areas for ozone or carbon monoxide. The Western Gulf Coastal Plain, Mississippi Valley Loess Plains, and Texas Blackland Prairie have the highest risk index values primarily due to higher percentages of area impacted.
Human Health Risk	High	Chemicals: Ozone, Carbon Monoxide. Exposure/Toxicity: Non-Cancer Risk - Estimated number of R6 residents in zone nonattainment areas is 9,333,899, for carbon monoxide is 1,792,600. The t risk populations are: Ozone - 356,812 asthma, 423,750 chronic bronchitis and emphysema; CO - 101,851 pregnant women, 108,176 coronary heart disease. Uncertainty: Moderate, identified, monitored exposure to urban populations, good animal data, acute toxicity documented.
Economic Risk	High	Annual Economic Damages: $794 million to $882 million. Most of these damages are attributable to estimates of damage to commercial crops from ozone exposures. It accounts for about $50 million in health and materials damages.

Region 6 Ranking of Problem Areas and Summary Comments

Risk Area	Ranking	Summary Comments
AIRBORNE LEAD Problem No. 16		
Ecological Risk	Low	The discharge of airborne lead is restricted to those immediate areas around lead smelters. There are only four such smelters in the **five** state area and they are located in two ecoregions - the Texas Blackland Prairies and Mississippi Valley Alluvial Plain.
Human Health Risk	Moderate-High	Chemicals: Lead Exposure/Toxicity: Cancer Risk - Lead is a B2 (probable) human carcinogen. Non-Cancer Risk: Of the 19,878 people living within 2 km of lead smelters in , 66 children would be expected to exceed 10 ug/dl blood lead levels. Children with blood Pb levels between 10-15 ug/dl have been shown to experience impaired neurobehavioral function. Of the 9,012,000 people in urban areas, 18,248 were projected to be at risk to experience hypertension and central nervous system effects; 13,185 projected to experience peripheral nervous system effects and elevated blood lead levels. Uncertainty: Moderate-good animal and epidemiology data, available exposure to include biological monitoring for smelter exposures only.
Economic Risk	Low	Annual Economic Damages: $0 to about $5.2 million. All are attributable to airborne lead's effect on health. Studies of children near lead smelters provide little evidence of adverse health impacts.

Region 6 Ranking of Problem Areas and Summary Comments

Risk Area	Ranking	Summary Comments
PARTICULATE MATTER (PM_{10}) Problem No. 17		
Ecological Risk	Moderate-Low	Particulate matter is only considered to pose ecological risk if non-attainment areas are present. The risk index values appear to be significantly determined by he percentage of ecoregion that is impacted. Only three ecoregions contain on-attainment zones including the Arizona/New Mexico Plateau, the Southern deserts and Western High Plains.
Human Health Risk	Moderate-High	Chemicals: Particulate Matter. Exposure/Toxicity: Cancer Risk - Estimated annual deaths from particulate (i.e., diesel exhaust) exposure total six in Region 6. Non-Cancer Risk: In R6 1,082,746 people live in cities that violate the PM 10 Standard. The population at risk to asthma is 21,173; coronary heart disease is 49,056. Uncertainty: High-good animal data demonstrating adverse effects of various particulates, limited epidemiology data.
Economic Risk	Moderate-High	Annual Economic Damages: Approximately $854 million. Most of these, $780 million per year are attributable to household and industrial cleaning costs. The costs capture damages associated with naturally occurring dust, which is common in parts of Region 6. For this reason IEc downgraded the ranking from 1 to a 2 category.

Region 6 Ranking of Problem Areas and Summary Comments

Risk Area	Ranking	Summary Comments
HAZARDOUS/TOXIC AIR POLLUTANTS Problem No. 18		
Ecological Risk	Moderate-High	The discharge of toxic air pollutants occur at some locations within most regions. There are risk index values for all but four ecoregions. The regions which appear to be of greatest ecological risk include the Central irregular Plains of Oklahoma the Western Gulf Coastal Plains, the Texas Blackland Prairies and the Mississippi Valley Loess Plains. These areas have high risk index values due to the potential to impact large areas of each of these regions.
Human Health Risk	Moderate-High	Chemicals: Arsenic, Asbestos, Benzene, 1,3 Butadiene, Cadmium, Chloroform, Carbon Tetrachloride, Chlorobenzene, Chlorophenol, Chromium, p Dichlorobenzene, Dioxin, 1,2 Dichloropropane, Ethylbenzene, Ethylene Dibromide, Ethylene Dichloride, Formaldehyde, Toluene, Gasoline Vapors, Exposure/Toxicity: Cancer Risk - The estimated risk of additional cancer cases used by air toxics is between 257 and 505. Non-Cancer Risk: TRI 1988 release data ranks R6 number 3 in toxic chemical releases to air. Texas ranked No. 1 nationally, Louisiana ranked No. 4. R6 industries (chemical, petrochemical petroleum refining, etc.) contribute 16% to the nations total air emissions. 263,374 people are at risk. Problem contributes significantly to global warming and ozone depletion as well as tropospheric ozone formation. Uncertainty: High-good animal data for specific chemicals, some worker exposure epidemiology data, lacking in ambient exposure information.
Economic Risk	Moderate-Low	Annual Economic Damages: $16 million to about $32.7 million. All are attributable to risks to health damages caused by various carcinogens. There may other damages from hazardous air pollutants to recreation or natural sources, but quantitative evidence of economic damage is unavailable at this time.

Region 6 Ranking of Problem Areas and Summary Comments

Risk Area	Ranking	Summary Comments
INDOOR AIR Problem No. 19		
Ecological Risk	N/A	
Human Health Risk	High	Chemicals: Formaldehyde, Benzene, Cigarette Smoke, Chloroform, Heptachlor, Chlordane, Tetrachloroethylene, Trichloroethylene. Exposure/Toxicity: Cancer Risk - The estimated annual cancer incidences from exposure is 1,475 (0.05% R6 population). Non-Cancer Risk - Estimated that exposure to indoor air causes discomfort, mild illness, eye irritation, dry throat, headache, fatigue, dizziness, sinus congestion, skin irritation, shortness of breath and nausea. 210,000 to 585,000 people in R6 may be affected by one or more f these symptoms. Entire R6 population is exposed to Indoor Air. EPA's total Exposure Assessment Methodology (TEAM) study concluded that "...indoor ir in the home and at work far outweighs outdoor air as a route of exposure to these chemicals." The study was referring to chemical exposure from consumer products, building materials, and personal activities (i.e., smoking, passive smoking, pumping gasoline). The air route accounted for > 99% of the exposures. (EPA Research and Development document no. EPA/600/6-87/002a) Uncertainty: Moderate-good animal and some industrial epidemiology data for each chemical listed. TEAM data indicates exposures are significantly greater than outdoor exposures.
Economic Risk	Moderate-High	Annual Economic Damages: $187 million to about $278 million. Health damages alone account for about $95 million per year with remediation of buildings containing asbestos and other hazardous materials accounting for the remainder.

Region 6 Ranking of Problem Areas and Summary Comments

Risk Area	Ranking	Summary Comments
RADON Problem No. 20		
Ecological Risk	N/A	
Human Health Risk	High	Chemicals: Radon. Exposure/Toxicity: Cancer Risk - Estimated number of annual lung cancer deaths in R6 due to exposure to indoor radon is approximately 868 to 4459 with median value of 2230. Non-Cancer Risk - not evaluated. There is an estimated 20 or fewer cases per year of serious mutagenic and teratogenic effects. The entire R6 population (28.5 million people) is exposed to radon. Epidemiological data and lab tests in animals have shown that radon exposure causes lung cancer. Uncertainty: Moderate- animal, toxicity data, and some epidemiology data; increasing evidence of indoor exposure contributions to lung cancer. Incomplete exposure information.
Economic Risk	Moderate-High	Annual Economic Damages: Approximately $49 million to about $278 million. Damages are all attributable to health risks of lung cancers. There is strong scientific evidence on the relationship between radon concentration and cancer risk. There are uncertainties over the population exposed at different radon levels due to incomplete results of state surveys.

Region 6 Ranking of Problem Areas and Summary Comments

Risk Area	Ranking	Summary Comments
RADIATION OTHER THAN RADON Problem No. 21		
Ecological Risk	N/A	
Human Health Risk	Moderate-High	Chemicals: Ionizing Radiation, Non-Ionizing Radiation. Exposure/Toxicity: Cancer Risk - Estimated annual cancer cases from ionizing radiation in R6, 1028 fatal cancer cases due to natural background, 4 from occupational exposures, 4 from medical exposures, and 17 from man-made sources. Ionizing radiation is known to cause genetic and teratogenic effects. As many as 215 combined fatal and non-fatal cancers may occur in R6 due to exposures to electric power line electromagnetic fields (non-ionizing radiation). Uncertainty: High for ionizing radiation, high for non-ionizing radiation.
Economic Risk	Low	Annual Economic Damages: $2.7 million to $19.1 million. All damages attributable to health risks for cancer. IEc discounted the damages from exposure to non-ionizing radiation from electromagnetic fields citing no scientific consensus of relationship to cancer.

Region 6 Ranking of Problem Areas and Summary Comments

Risk Area	Ranking	Summary Comments
PHYSICAL DEGRADATION OF TERRESTRIAL ECOSYSTEMS Problem No. 22		
Ecological Risk	High	The definition of this problem did not specify the activities to be considered in evaluating the scope of risk. Potential impacts associated with agriculture, silviculture, and urbanization were evaluated. Problems such as metals mining, uranium mining, grazing and highway construction was not evaluated due to imitations in the databases. The highest risk due to plowing and harvesting is in he Central Oklahoma/Texas Plains, Mississippi Alluvial Plain and Central Irregular Plains. The silviculture practices of clear cutting and conversion of ands to pine monoculture has a significant impact on the environment. The risk posed by those activities tend to be centered where timber production is the greatest in the South Central Plains, Boston Mountains, and Ouachita Mountains.
Human Health Risk	N/A	
Economic Risk	N/A	

Region 6 Ranking of Problem Areas and Summary Comments

Risk Area	Ranking	Summary Comments
STRATOSPHERIC OZONE DEPLETION Problem No. 23		
Ecological Risk	High	Problem not evaluated by the risk index methodology.
Human Health Risk	High	Chemicals: Chlorocarbons, other Halocarbons, Nitrogen Oxides. Exposure/Toxicity: Cancer Risk: Annual estimates of cancer cases and associated mortalities for R6 are: 1,167 melanoma skin and cancer cases, 232,772 on-melanoma if no CFC controls are implemented (276 and 4,609 mortalities er year respectively). Fair skinned R6 residents are most at risk from increased exposure to UV-B radiation, all residents can suffer the harmful effects. Noncancer Risk: Eye disorders, cataracts, and sunburns can be caused by exposure o UV-B radiation. Uncertainty: High-good laboratory UV-B animal and epidemiology data; the future adverse effects from stratospheric ozone depletion and resulting UV-B exposure can only be estimated.
Economic Risk	High	Annual Economic Damages: $211 million to about $1717 million. The damages r two categories: health damage due to skin cancer and cataracts and commercial harvest damages to crops and Fisheries. Health damages range from 50 million to $1.5 billion. ne commercial damage estimate ranges from $161 million to $234 million.

Region 6 Ranking of Problem Areas and Summary Comments

Risk Area	Ranking	Summary Comments
GLOBAL WARMING Problem No. 24		
Ecological Risk	High	Problem not evaluated by the risk index methodology.
Human Health Risk	-----	Problem was not evaluated.
Economic Risk	High	Annual Economic Damages: $341 million to about $3373 million. The damages include damages to commercial harvest of corps and fisheries, damages to sources, including wetlands, beaches, and other coastal lands effected by sea level rise. Region 6, with its extensive coastal wetlands, is extremely vulnerable o the consequences of global warming.

II. APPROACH AND METHODS

The project approach required that Region 6 scientists have direct control over methodology development and the gathering and interpretation of data. The role of management and the Steering Committee was as overseer of the process. The methods employed to evaluate Regional risks were open for peer review and the authors were required to state their assumptions and document their data sources.

Project Organization

A Project Director was chosen and given the responsibilities of organizing the Region's comparative risk project, assisting in the development of methodologies, preparing and presenting frequent progress reports to regional managers, and finalizing a comparative risk report for submission to Headquarters EPA- Gerald Carney, Ph.D., a Regional toxicologist with experience in coordinating the Region's Community Right-to-Know Toxic Release Inventory Program, was given the task.

The director submitted a workplan to senior management and Headquarters EPA which required a Steering Committee, workgroup chairpersons and workgroup membership be established. The Steering Committee consisted of Region 6 Division Directors, the Regional Administrator, and the Deputy Administrator. Workgroup chairs were Jerry Saunders (Ecological workgroup), Don Williams (Human Health workgroup), Jim Pendergast and Donna Ascenzi (Risk Management workgroup).

The director and workgroup chairs proposed that a Region 6 economic evaluation be performed. The Region did not have a staff economist, therefore, Industrial Economics, Inc. (IEc) was contracted to do the analysis.

A peer review plan consisted of frequent update reports to the Steering Committee, submission of drafts to the Region's Risk Coordinating Committee, presentations to State agency representatives, submittal of draft reports to an outside federal agency, Soil Conservation Service, and an academic environmental institute (The Environmental Institute, University of Texas at Arlington).

Administrative Ground Rules

Initial meetings with the director, Steering Committee, and workgroup chairs established key agreements and project ground rules:

1) Only residual risk would be studied.

2) Three risk evaluations would be performed; ecological, human health, and economic.

3) Risk management factors would be analyzed, but would not be included in the Regional rankings.

4) Risk management factors would be used in strategic planning and not in the assessment of

risk.

5) Primary responsibility for adherence to scientific principles and prescribed methodologies would reside with the Project Director.

6) Equal and consistent application of risk methodologies would be an overview responsibility of the Steering Committee.

7) Changes in the risk rankings could only occur as a result of new information or data, or through a general change in methodology which would effect all problem areas equally.

Workgroup Approach

Each workgroup chairperson and each group member were asked to seemingly do the impossible. Clearly there was no margin for error. Describing and ranking risk for a five state area, for all the defined environmental risk sources would require dedication as well as novel approaches. Decisions were made to limit the evaluations in several areas. For example, the health group decided to consider, were appropriate, a minimum of ten chemicals of the greatest concern for a problem area and to consider data at the county level for many problems.

The ecological group worked at the ecoregion level. These studies were referred to as "top down" approaches realizing that community and species level analyses may not be possible in the limited analysis time or as meaningful when evaluating twenty-three defined ecological systems.

Each regional program was asked to identify an individual to serve on a comparative risk workgroup. Each program was also requested, through a "Branch Chiefs" memo, to prepare a risk report. Mr. Mike Miller of the Radon Program (Air Division) prepared an example report for the other programs. It was the workgroup members who wrote most of the papers known as "program reports". These reports are the basis for regional data. Although all the time contributed by workgroup members was volunteer, or in addition to their described performance standards, project leaders were convinced that more could be gained by Region 6 if risk data was gathered, analyzed, and interpreted for Region 6. This approach created a cadre of risk assessors and cross media analysts who continue to serve the Region in this project and other risk based endeavors.

Methodologies

<u>Ecological Methodology</u>

The ecological risk assessment workgroup evaluated the residual risk posed by the twenty-two environmental problem areas identified by EPA Headquarters and the Regional comparative risk directors. Residual risk at the ecoregion level based on geographical/ecological parameters defined by J. M. Omernick and A- L. Gallant (1986), was evaluated.

The workgroup made the assumption that ecological risk exists when ecological threat impairs the ability of an ecoregion to perform basic functions. This approach to risk evaluation was taken because there is more to an ecosystem than aquatic or terrestrial organism production and impacts to all basic ecological functions needed to be examined to fully evaluate ecological risk.

To identify basic ecosystem functions a brief review of the ecological literature was performed and the workgroup revised a list of basic ecological functions, identified by Rodale (1972) and Southwick (1976), selecting those functions that related to the non-human environment.

With a listing of basic problems and basic ecosystem functions, ecological risk for each ecoregion was evaluated, by evaluating the impact of each problem on each ecosystem function. To determine generally which stressors or problems would impact which functions a simple evaluation matrix was designed by plotting problems or stressors on the "X" axis and ecological functions on the "Y" axis. The workgroup discussed how each problem would have an impact on each function. During workgroup discussions it became apparent that there was a wide range of variability associated with the impacts of the various problems on any given function. An evaluation matrix with numeric values was completed for each ecoregion.

A mathematical model was developed. 'ne variables included those common to all 22 problem areas: area of impact and degree of impact. A variable was also included to represent the differences from one ecoregion to another to withstand environmental stress, degree of vulnerability.

After conceptualization of the model, information was gathered from the appropriate EPA programs on area and degree of impact for each problem. Upon receipt of the data the information was reviewed and quality controlled to ensure that appropriate values were entered into the computer for calculation of ecological risk index values.

The degree of vulnerability values were taken from established data that could be obtained on endangered species, soil erosion rates, primary productivity, stream density and assimilative capacity. With data input complete, an ecological risk index value was generated for each problem per ecoregion for the five state area.

When data for all twenty-two problems had been obtained, entered, and risk indices derived, it was possible to rank the ecological risk posed by each of the problems.

The Geographic Information System (GIS) was used to graphically display data collected for each Region 6 ecoregion.

Human Health Methodologies

The Human Health Risk Workgroup evaluated the carcinogenic and non-carcinogenic health risk posed by 24 environmental problem areas. The group developed a relative ranking of the' risks based on both quantitative and qualitative assessments.

The workgroup collected the available data and assessed the risk associated with each problem. The workgroup recognized that very little data was available for many, if not most, of the problem areas. The methodologies were consistent with those used in Regions 1, 3, and 10, and the national comparative risk report, Unfinished Business (1987). They also used the standard components of EPA's risk assessment methodology.

Cancer Methodology

For each of the problem areas, where possible, a short list of chemicals was identified which represented the emissions associated with each problem. The indicator contaminants were selected based on how well the substances characterized a problem and on the availability of data. The contaminant's carcinogenic potency was characterized using EPA's cancer potency factors (Pf).

The evaluation involved assessing the exposures posed in each problem area by the estimation of the concentrations at which exposures occurred, the resulting contaminant doses, and the likely population exposed to the contaminants.

The workgroup estimated the degree of uncertainty associated with the risk estimates in each problem area. This uncertainty was described qualitatively as Low, Medium, or High (i.e., Low uncertainty meant the degree of confidence in the assessment was high). The basic criteria for the assessment of uncertainty included the availability and quality of; 1) animal toxicological data for specific chemicals, 2) epidemiological data, 3) ambient and biological monitoring data, 4) medical or regulatory case study information, 5) the number of chemicals reviewed (coverage of problem area), and 6) the degree of extrapolation performed.

Non-Cancer Methodology

The non-cancer methodology followed the general approach as the cancer methodology. The workgroup considered three variables in the determination. One was the population exposed. Another was the hazardous index (HI) estimation based on the severity of the health effects endpoint. The third was the potency of the contaminant based on the ratio of the concentration (ambient concentration) over the reference dose (RfD).

The data available to Region 6 was often in the form of exceedances of various ambient concentrations (air or water) or a monitoring or reporting violation. The workgroup was able to estimate the populations potentially impacted by such exceedances or other violation. Populations at risk were placed on a 4 point scale.

The Human Health Workgroup used Regional data to characterize the problem areas by criteria and scaling factors. 'ne severity, potency, population, and exposure evaluations were therefore combined to determine an estimate of the relative non-carcinogenic risk for each problem area.

The estimates of uncertainty were identical to that performed in the cancer evaluation methodology.

Combined Rankings

Upon completion of the carcinogenic and non-carcinogenic risk analyses, the workgroup organized problem areas with similar estimated risks into four categories relying on apparent "breaks" in the cancer and non-cancer calculated/estimated risks. Workgroup members agreed that further rankings within each category could be done based on acute or chronic threat and the degrees of uncertainty associated with the data. The process for combining the carcinogenic and non-cancer rankings into a single "combined risk ranking" was a subjective task. Regions 1 and 10 chose to categorize their combined risk areas, but did not rank them within each category. The Region 6 workgroup decided to follow this method. The subjective nature of combining cancer and non-cancer rankings and adding separate degrees of uncertainty convinced the workgroup not to develop a single ordinal ranking of health problem areas.

Risk Management Method

The Region 6 Risk Management workgroup was charged with identifying and evaluating the associated risk management factors for the twenty-two environmental problem areas listed in the "core list" which Regions 2, 4, 5, 7, 8, and 9 are also using. Risk management factors are concerns such as public perception, legal authority, available technology, or EPA resources which affect the ability of the Region to control environmental exposures and reduce risk. The management factors will serve as additional information to be used by Region 6 senior staff along with the economic, health, and ecological impacts for developing and implementing strategies to control adverse environmental exposures.

Each of the twenty-two environmental problem areas were evaluated on a scale of 1 to 5 for each management factor, with 5 indicating that the problem area was 'difficult' to manage and I indicating that the problem was "easy" to manage. Factors identified as being difficult to manage are of concern to the workgroup because if a problem area poses a high health or ecological risk, the difficulty in managing the risk hinders the Region's ability to reduce the risk.

In assessing the factors, the workgroup focused on residual risk. This is the risk associated with existing levels of regulatory control and compliance. In essence, it is a snapshot of the Region's environmental control in 1989.

In addition to the management factors, the workgroup identified which existing regional budget items are associated with each of the twenty two problem areas. This information was compiled for use by regional senior managers to possibly influence the assignments of future resources towards reducing environmental risks.

Because there is no one established methodology for addressing risk management factors, the Region 6 workgroup needed to develop a methodology for an objective evaluation of environmental problem areas, fits the data available from Region 6 programs, and is compatible with the methodologies used by other regions. The workgroup first reviewed the approaches used by other regions. Region 3 chose to use an existing regional management factor analysis which they did not document. Region 1 evaluated and documented the assessment of

management factors. Only summary information was available from Region 10. The three regions basically followed the same approach for welfare impacts. The workgroup followed the approach used by Region 1 for management with two changes:

> The workgroup believed that the Region 1 evaluation of remediation costs overlapped with the ranking conducted for welfare risks, and therefore, grouped all cost evaluations into the welfare analysis.
>
> The workgroup did not believe that the necessary resources to remediate environmental risk could be objectively identified, and decided to identify only the existing resources.

The workgroup used each program's knowledge of public perception, resources, technology, and legal authority as the sources of information. The Region's external affairs and legal counsel offices were used to augment program information on public perception and legal authority. Despite these efforts, most of the evaluation was based upon limited information.

After all the information concerning public perception, legal authority, and effective technology was collected, an initial ranking was made by the workgroup individual assigned to the problem area. This ranking was then discussed and reviewed by the entire workgroup, and a consensus ranking was developed.

The workgroup did not combine the rankings for each of the management factors into a single overall ranking. The workgroup members did not believe that a combined ranking would properly reflect the relative weight and/or significance of each factor in the decision-making process.

Economic Methodology

Industrial Economics, Incorporated (IEc) quantified the economic damages caused by twenty-five problem areas. Data was presented as a low and high range of annual damages. The rankings were scaled based on magnitudes of economic damages according to the following scheme:

1 = > $ 500 million
2 = $ 100- $ 500 million
3 = $ 10- $ 100 million
4 = $ 0- $ 10 million

In ranking the problem areas, if the low-high range lay within a ranking category range, the problem area in almost all cases received that ranking. Where a damage range spanned two ranking ranges IEc used its best judgment to determine whether uncertainties or areas of damage that could not be quantified should cause the problem area to receive the higher or lower ranking. In two cases IEc used its professional judgment to downgrade a problem area's ranking. One change was based on uncertainties over the application of national damage estimates and another because of disagreement with a to Region 6 estimate methodology.

The economic welfare analysis is one of four assessments conducted by EPA Region 6. Included in the Region 6 Comparative Risk Project were rankings of health effects, ecological damages, risk management factors, and economic welfare damages. These economic/welfare damages are health care costs and lost wages; damages to commercial harvests of fish, crops, and timber; natural resource damages; damages to materials in use; reductions in recreational opportunities; remediation damages; and aesthetic damages. The assessment of economic costs associated with pollutant-caused adverse health effects involved weighing direct costs of treating diseases and indirect costs of lost wages and productivity. It does not attempt, however, to quantify the full value of human life lost to premature death from cancer or any other environmentally caused illness or accident. These effects are assumed to be captured in the separate ranking of human health effects. Similarly, not all damages to natural resources and natural ecosystems can be quantified, and these damages are accorded due weight in the ecological ranking.

III. PROBLEM AREA RANKINGS

ECOLOGICAL SUMMARY

The ecological risk assessment workgroup evaluated the residual risk posed by the 22 environmental problem areas identified by EPA Headquarters and the Regional Comparative Risk (RCRP) directors. 'ne workgroup evaluated residual risk at the ecoregion level for the following reasons:

1. Ecoregions are geographically and ecologically based.
2. Ecoregions could serve as a template for data collection.
3. This approach lent itself well to geographic information system applications.
4. There are a wide variety of ecoregions within the rive state region (portions of twenty-rive ecoregions).
5. The workgroup was concerned about the general health of the large ecological units recognizable in the landscape.
6. There was a short time frame to complete the initial evaluation of ecological risk.

Map 1 displays the ecoregions evaluated in Region 6.

Methodology

The assumption that ecological risk exists when ecological threat impairs the ability of an ecoregion to perform basic ecological functions was made. This approach to risk evaluation was taken because there is more to an ecosystem than aquatic or terrestrial organism production and impacts to all basic ecological functions need to be examined to fully evaluate ecological risk. To identify basic ecosystem functions the workgroup made a brief review of the ecological literature and revised a list of basic ecological functions identified by Rodale (1972) and Southwick (1976), selecting those functions that related to the non-human environment. The .list of basic ecosystem functions identified and impaired by the twenty-two problems (or stressors) includes;

1. distribution of water, minerals, and nutrients via the hydrologic cycle,
2. oxygen production and carbon dioxide consumption,
3. filtering and detoxifying of pollutants,
4. soil production and maintenance, and
5. production of aquatic organisms,
6. production of terrestrial organisms,
7. conversion of energy (sunlight) into organic matter.

With a listing of basic problems and ecosystem functions, ecological risk for each ecoregion was evaluated, by evaluating the impact of each problem on each ecological function (Figure 1).

A mathematical model was formulated (Figure 2) and supported by a Region 6 developed computer system. The variables included in the model represented variables common to all 22 problem areas; area of impact and degree of impact. A variable was included to represent the

FIGURE 1

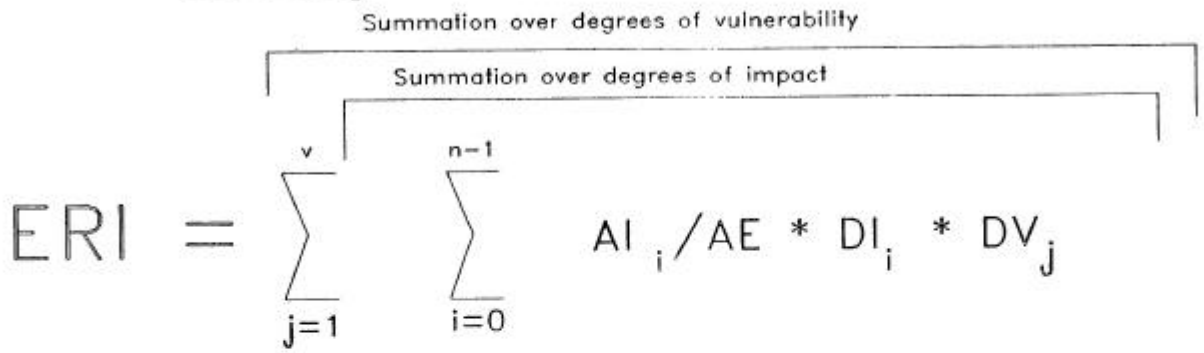
RISK MATRIX

EPA Region 6

Ecological Problems	ECOLOGICAL FUNCTIONS	HYDROLOGY	O2 PRODUCTION / CO2 CONSUMPTION	FILTERING/ DETOXIFYING POLLUTANTS	SOIL PRODUCTION	FISHERIES PRODUCTION	WILDLIFE PRODUCTION	PRIMARY PRODUCTION
1) Industrial Point Discharge to surface waters		O	O	X	O	X	X	X
2) POTW Discharges to surface waters		O	O	X	O	X	X	X
3) Drinking Waters, Public & Private		O	O	O	O	O	O	O
4) Non-Point Source discharges		O	O	X	O	X	X	X
5) Physical degradation of Waters & Wetlands		X	O	X	X	X	X	X
6) Other Ground-Water contamination		O	O	X	O	X	X	X
7) Storage Tanks		O	O	X	O	X	X	X
8) RCRA Hazardous Waste Sites		O	O	X	X	X	X	X
9) CERCLA Hazardous Waste Sites		O	O	X	X	X	X	X
10) Other Waste - Municipal		O	O	X	X	X	X	X
11) Other Waste - Industrial		O	O	X	X	X	X	X
12) Accidental Releases		O	O	X	X	X	X	O
13) Application of Pesticides		X	O	X	X	X	X	X
14) Sulfur & Nitrogen Oxides (Acid Deposition)		O	O	X	X	X	X	X
15) Ozone & Carbon Monoxide		O	O	X	X	X	X	X
16) Airborne Lead		O	O	X	X	X	X	X
17) Particulate Matter		O	O	X	X	X	X	X
18) Hazardous/Toxic Air Pollutants		O	O	X	X	X	X	X
19) Indoor Air Pollutants		O	O	O	O	O	O	O
20) Indoor Radon		O	O	O	O	O	O	O
21) Radiation other than Radon		O	O	O	O	O	O	O
22) Physical Degradation of Terrestrial Ecosystems/Habitat		X	O	X	X	O	X	X

X designates anticipated ecological impact
O designates no anticipated ecological impact

Ecological RISK INDEX FORMULA



ERI – Ecological Risk Index
n – Number of Degrees of Impact
AI_i – Area of Impact
AE – Area of Ecoregion
DI_i – Degree of Impact
DV_j – Degree of Vulnerability
v – Number of Degrees of Vulnerability

FIGURE 2

differences from one ecoregion to another to withstand environmental stress, degree of vulnerability.

After conceptualization of the model, the workgroup proceeded to obtain information from the appropriate programs on area and degree of impact for each problem. Upon receipt of the data the information was reviewed and quality controlled to ensure that appropriate values were entered into the computer for calculation of ecological risk index values. The degree of vulnerability values were taken from established data that could be obtained on endangered species, soil erosion rates, primary productivity, stream density and assimilative capacity. With data input complete, an ecological risk index value was generated for each problem per ecoregion and for the five state area. A matrix with numeric values was completed for each ecoregion. Table 1 is a comparative risk matrix for 23 ecoregions and 13 ecological problems.

When data for the majority of the 22 problems had been obtained, entered, and risk indices derived, it was possible to rank or estimate the ecological risk posed by each of the problems (Table 2). The Geographic Information System (GIS) was used to graphically display data collected for each Region 6 ecoregion (Maps 1 through 17).

Results

Category 1 problems are those which were found throughout most ecoregions and in many situations impacted over one-third of the individual ecoregions. Large rates of conversion of land to agricultural land exceeds 30,000 acres per year in some states. The impact from this conversion is significant for it usually involves elimination of vegetative, aquatic and terrestrial populations with associated reductions in natural assimilative capacity and increased soil erosion. This land area is then subjected to the application of fertilizers, pesticides, and herbicides. The magnitude of these problem impacts cannot be underestimated.

Category 2 problems to some extent are an outgrowth of Category 1 problems. For example, non-point source stress would be expected to be great in areas with high rates of pesticide application, increasing agricultural production, and high rates of urbanization. The hazar-dous/to)dc air pollution problem ranks high because of the large number of facilities discharging chemicals to the air in Region 6 (over 1,300). Most of these facilities are not currently regulated by sufficient standards.

Category 3 problems represent a mixture of problems which are limited in scope, from 5 to 20 percent of the individual ecoregions. In general these problem areas have some established standards or State/Federal programs to control the emission.

Category 4 problems represent problems of limited area with effective control or responsive programs in place which help to reduce the residual risk.

TABLE 1

RISK MATRIX - EPA Region 6
for Region 6, FY90
Ecological Risk Index

ECOLOGICAL REGIONS / ECOLOGICAL PROBLEMS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	TOTAL
21) SOUTHERN ROCKIES, NM	0.0	0.1	0.0	6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.5
22) ARIZONA/NEW MEXICO PLATEAU,NM	0.0	0.6	0.0	6.1	0.6	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.5	0.0	0.1	0.4	0.0	0.0	0.0	0.7	0.0	9.3
23) ARIZONA/NEW MEXICO MOUNTAINS, NM & TX	0.0	0.2	0.0	2.9	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9
24) SOUTHERN DESERTS, NM & TX	0.0	0.7	0.0	1.1	0.5	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.3	0.0	0.5	0.0	0.1	0.2	0.0	0.0	0.0	0.2	0.0	3.8
25) WESTERN HIGH PLAINS, NM & TX	0.0	0.0	0.0	0.4	0.8	0.0	0.0	0.1	0.0	0.0	0.0	0.1	8.2	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	2.5	0.0	12.4
26) SOUTHWESTERN TABLELANDS, TX & OK	0.0	0.2	0.0	1.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.1	2.3	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.6	0.0	4.8
27) CENTRAL GREAT PLAINS, TX & OK	0.1	0.1	0.0	1.1	0.8	0.0	0.0	0.1	0.0	0.0	0.0	0.0	12.9	0.0	0.2	0.0	0.0	0.5	0.0	0.0	0.0	3.5	0.0	19.4
28) FLINT HILLS, OK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29) CENTRAL OLKAHOMA/TEXAS PLAINS, TX & OK	0.0	0.2	0.0	0.1	1.1	0.0	0.0	0.2	0.0	0.0	0.0	0.2	4.2	0.0	1.0	0.0	0.0	2.2	0.0	0.0	0.0	1.2	0.0	10.3
30) CENTRAL TEXAS PLATEAU, TX	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.1	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	2.4
31) SOUTHERN TEXAS PLAINS, TX	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.1	2.6	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.9	0.0	4.6
32) TEXAS BLACKLAND PRAIRIES, TX	0.0	1.7	0.0	0.8	1.2	0.0	0.0	0.9	0.0	0.0	0.0	0.9	7.6	0.0	2.5	0.0	0.0	6.1	0.0	0.0	0.0	9.3	0.0	30.8
33) EAST CENTRAL TEXAS PLAINS, TX	0.3	1.2	0.0	0.7	3.1	0.0	0.0	0.2	0.0	0.0	0.0	0.2	3.0	0.0	0.3	0.0	0.0	0.4	0.0	0.0	0.0	0.9	0.0	10.3
34) WESTERN GULF COASTAL PLAIN, TX & LA	1.1	2.1	0.0	1.2	11.2	0.0	0.0	1.7	0.0	0.0	0.0	2.1	6.2	0.0	4.8	0.0	0.0	6.8	0.0	0.0	0.0	2.4	0.0	39.5
35) SOUTH CENTRAL PLAINS, TX, LA & AR	0.3	0.8	0.0	0.3	6.1	0.0	0.0	0.3	0.0	0.0	0.0	0.2	1.6	0.0	0.3	0.0	0.0	1.7	0.0	0.0	0.0	13.1	0.0	24.8
36) OUACHITA MOUNTAINS, AR & OK	0.0	0.0	0.0	0.9	3.6	0.0	0.0	0.2	0.0	0.0	0.0	0.2	1.6	0.0	0.0	0.0	0.0	3.8	0.0	0.0	0.0	8.5	0.0	18.8
37) ARKANSAS VALLEY, AR & OK	0.0	0.1	0.0	1.8	3.2	0.0	0.0	0.1	0.0	0.0	0.0	0.1	2.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	4.7	0.0	13.6
38) BOSTON MOUNTAINS, AR & OK	0.0	0.0	0.0	0.3	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0	0.0	6.2	0.0	13.1
39) OZARK HIGHLANDS, AR & OK	0.0	0.1	0.0	0.0	3.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	1.5	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0	4.3	0.0	11.3
40) CENTRAL IRREGULAR PLAINS, OK	0.6	0.5	0.0	2.0	1.1	0.0	0.0	0.6	0.3	0.0	0.0	1.6	10.2	0.0	0.0	0.0	0.0	8.6	0.0	0.0	0.0	4.3	0.0	29.9
65) SOUTHEASTERN PLAINS, LA (65 & 75)	1.6	2.6	0.0	2.7	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	8.0
73) MISSISSIPPI ALLUVIAL PLAIN, AR & LA	0.7	0.6	0.0	3.0	9.7	0.0	0.0	0.3	0.0	0.0	0.0	0.7	16.3	0.0	0.6	0.0	0.0	2.3	0.0	0.0	0.0	6.6	0.0	40.6
74) MISSISSIPPI VALLEY LOESS PLAIN	0.5	0.6	0.0	2.1	0.0	0.0	0.0	0.8	0.0	0.0	0.0	2.9	0.0	0.0	6.4	0.0	0.0	5.9	0.0	0.0	0.0	0.0	0.0	19.1
ECOLOGICAL PROBLEM -- TOTALS	5.3	12.4	0.0	34.7	53.5	0.0	0.0	6.2	0.4	0.0	0.0	9.7	81.9	0.0	17.0	0.0	0.1	45.9	0.0	0.0	0.0	70.2	0.0	

1) Industrial Point Discharge to Surface Waters
2) POTW Discharges to Surface Water
3) Drinking Waters, Public & Private
4) Non-point Source discharges
5) Physical Degradation of Water & Wetlands
6) Other Ground-Water Contamination
7) Storage Tanks
8) RCRA Hazardous Waste Sites
9) CERCLA Hazardous Waste Sites
10) Other Waste - Municipal
11) Other Waste - Industrial
12) Accidental Releases
13) Application of Pesticides
14) Sulfur & Nitrogen Oxides (Acid Depostion)
15) Ozone & Carbon Monoxide
16) Airborne Lead
17) Particulate Matter
18) Hazardous/Toxic Air Pollutants
19) Indoor Air Pollutants
20) Indoor Radon
21) Radiation other than Radon
22) Physical Degredation of Terrestrial Ecosystems/Hab
23) Oil & Gas

Table 2. Ecological Risk Rankings

Problems Posing Residual Ecological Risk	Ecological Risk Index Value
Category 1: (Highest Risk)	
Application of Pesticides	81.90
Physical Degradation of Terrestrial Ecosystems	70.20
Physical Degradation of Water and Wetlands	53.50
*Global Warming	----
*Stratospheric Ozone Depletion	----
Category 2:	
Non-Point Source Discharges	34.70
Hazardous / Toxic Air Pollutants	45.92
Category 3:	
Ozone and Carbon Monoxide	17.00
POTW Discharges to Surface Waters	12.40
Accidental Releases	9.66
RCRA Hazardous Waste Sites	6.21
Industrial Point Discharges to Surface Waters	5.31
*Municipal Waste Sites	----
*Industrial Waste Sites	----
*Ground Water Contamination	----
Category 4: (Lowest Risk)	
CERCLA Hazardous Waste Sites	0.41
Particulate Matter	0.14
Airborne Lead	0.01
*Storage Tanks	----

* Estimated Ranking

Problem Areas For Which No Evidence Was Provided To Indicate Ecological Harm:

$S0_2$ and NO_x , and Radiation other than radon

Problem Areas For Which The Workgroup Concluded There Was Negligible Or No Risk:

Drinking Water (public and private), Indoor Air Pollutants, Indoor Radon

Of particular concern are problems which go beyond the scale of ecoregion impacts and which are not ranked at this level. Such problems include stratospheric ozone depletion and global warming. The research in those areas indicates that climatic changes over the next century will result in increased temperatures. These problems should be of particular concern in this Region because:

1. Region 6 has a large number of air toxic dischargers which may contribute significantly to the global problems.
2. Region 6 has a high percentage of the nation's coastal wetland resources which could be lost due to temperature increase and the associated sea level rise.
3. Stratospheric ozone depletion and the resultant increase in UV-B radiation could erode the foundation of the marine food web (marine organism larvae and phytoplankton) again impacting the Region's wetlands.
4. and, the basic factors which determine ecoregion boundaries in Region 6 are primarily determined by climate. Change in the climate causing shifting of these boundaries would have devastating consequences.

The risk associated with climatic change appears to be very high with lasting damage to the environment.

Conclusions

The lack of an established methodology for evaluating ecological risk led the ecological risk workgroup to develop a mathematical model to assist in the ranking process. The model's variables were common to all problem areas and represented each ecoregions ability to withstand stress.

.Databases were difficult to obtain, due to ongoing work responsibilities of workgroup members and Regional staff. Databases were obtained from within EPA, state, and other federal agency ,,sources. The data submitted frequently consisted of estimates due to time limitations and the regulatory nature of the information source (data was not usually gathered with risk research as its primary use). Nevertheless, a relative ranking of risk was completed that sorted problem areas on the basis of area, degree of impact, and degree of vulnerability of the areas of impact. The problems of greatest ecological risk in Region 6 appear to stem from agriculture and silviculture. The conversion of forested wetlands and uplands to agricultural land or monoculture pine forests and subsequent application of pesticides and herbicides also results in non-point source water quality concerns. Of additional importance is the unregulated discharge of toxic air pollutants which may play a long term role in global warming and stratospheric ozone depletion.

Discussion of Residual Ecological Risk Posed by Each Problem

Industrial Point Source Discharge to Surface Waters

The risk index information for this problem reflects information provided by the water programs from each state's 305(b) report. Areas of impact are those stream segments in each ecoregion that are not meeting water quality standards due, at least in part, to industrial point source discharges. The ecoregions with the highest risk index values are those with the greatest percentage of stream miles impaired by industrial point source discharges. Consequently, the Western Gulf Coastal Plains, the Mississippi Alluvial Plains, the Southeastern Plains and Central Irregular Plains of Oklahoma have the highest risk index values, which is visually portrayed by Map 2.

POTW Discharges to Surface Waters

Like the industrial point source problem, the risk index information for this problem reflects information contained in the states 305(b) reports. Areas of impact are those stream segments in each ecoregion that are not meeting water quality standards due, at least in part, to POTW discharges to surface water. The ecoregions with the highest risk index values are those with the greatest percentage of stream miles impaired by POTW discharges. As a result, the Western Gulf Coastal Plain, Southeastern Plains, East Central Texas Plains, and Texas Blackland Prairies are the ecoregions at greatest risk due to POTW discharges, which is visually depicted in Map 3.

Non-Point Source Discharges to Surface Waters

Like the aforementioned water problems, the risk index information for this problem reflects information obtained in the states 305(b) reports. Areas of impact are those stream segments in each ecoregion that are not meeting water quality standards due, at least in part, to nonpoint source problems. Unlike the aforementioned problems, ecoregions with the highest risk index values are not those with the greatest percentage of stream miles impacted, although they are close to the top of the list. The ecoregions with the greatest risk index values are the Southern Rockies and Arizona/New Mexico Plateau which is visually portrayed by Map 4. This ranking appears to be due not only to percentages of stream miles impacted but also due to the vulnerability of the ecoregions.

Physical/Degradation of Water and Wetlands

The risk index information for this problem reflects information extracted from Fish and Wildlife Service (FWS) reports. Area of impact is the estimated remaining acreage of wetlands per ecoregion. In some cases it is not possible to locate information on an ecoregion basis. Specifically it was not possible to discern acerate amounts in the Southeastern Plains and Mississippi Valley Loess Plains. This is unfortunate because both ecoregions are known to contain extensive acerate of wetlands. Excluding these two areas, the ecoregions with the greatest risk index values are the Western Gulf Coastal Plain and Mississippi Alluvial Plain (Map 5). These high values reflect the high percentage of these ecoregions remaining in wetland

acreage (approximately twenty percent).

RCRA Hazardous Waste Sites

The distribution of 389 RCRA facilities was plotted on an ecoregion map by program personnel and provided to the workgroup. Those ecoregions with the greatest number of facilities have the greatest risk index values. The Western Gulf Coastal Plains (with over one third of all RCRA facilities), the Texas Blackland Prairies, the Central Irregular Plains, and the Mississippi Valley Plain ranked high due to the large number of facilities. This is visually portrayed in Map 6.

CERCLA Hazardous Waste Sites

CERCLA risk index information resulted in risk index values for fourteen ecoregions, each of which contains at least one CERCLA site. Information was provided by the program on actual size of each site plus an estimated off-site zone of impact of one mile in radius around each facility. nose ecoregions with the highest risk index values were those with the greatest percentage of ecoregion impacted. However, the high vulnerability of the central Irregular Plains also contributed to its high ranking. The distribution of residual risk from CERCLA sites across the region is visually depicted on Map 7.

Accidental Releases

The accidental releases category included essentially any contaminants accidentally released into the environment during transport or production. The distribution of residual risk from accidental releases occurs in most ecoregions within EPA Region 6. Information was provided by the program which described the average size of each spill site and the frequency of occurrences by county. Impacts were projected based upon a 50 year period. The ecoregions with the highest risk index values were the Mississippi Valley Loess Plain of Louisiana, the Western Gulf Coastal Plain of Texas and the Central Irregular Plains of Oklahoma.

Application of Pesticides

The application of pesticides and herbicides occurs across most ecoregions but it is particularly widespread in the Mississippi Alluvial Plain, Western High Plains, Central Great Plains and Central Irregular Plains of Oklahoma. High percentages of these areas are in agricultural production. Consequently, they have high risk index values. The distribution of residual risk for application of pesticides across the region is shown by Map 9.

Ozone and Carbon Monoxide

.These discharges were only considered problems when there were non-attainment areas for ozone or carbon monoxide. There were non-attainment areas for these pollutants in ten ecoregions (Map 10). The Western Gulf Coastal Plain, Mississippi Valley Loess Plains, and Texas Blackland Prairies have the highest risk index values primarily due to higher percentages of area impacted.

Airborne Lead

The discharge of airborne lead as it is currently defined, is restricted to those immediate areas around lead smelters. There are only four such smelters in the rive state area and they are located in two ecoregions the Texas Blackland Prairie and Mississippi Valley Alluvial Plain. Consequently, Map 11 depicts only two ecoregions where airborne lead may pose an ecological risk.

Particulate Matter

Discharges of particulate matter are considered an ecological risk if non-attainment areas are present. Three ecoregions contain non-attainment zones including the Arizona/New Mexico Plateau, the Southern Deserts and Western High Plains. Again, the risk index values appear to be significantly determined by the percentage of ecoregion that is impacted. Map 12 portrays the geographic distribution of ecological risk per ecoregion due to particulate matter.

Toxic Air Pollutants

The discharge of to)dc air pollutants occurs at some locations within most ecoregions. Consequently, there are risk index values for all but four ecoregions. Those ecoregions which appear to be of greatest ecological risk include the Central Irregular Plains of Oklahoma, the Western Gulf Coastal Plains, the Texas Blackland Prairies and the Mississippi Valley Loess Plains (Map 13). These areas have high risk index values due to the potential to impact large areas of each of these ecoregions.

Physical-Degradation of Terrestrial Ecosystems

The definition of physical degradation of terrestrial ecosystems did not specify the activities to be considered in evaluating the scope of this problem. To a great extent, the activities considered only included those databases that were found within the time allowed to complete the project. Consequently, the potential impacts associated with agriculture (plowing and harvesting), silviculture (harvesting), and urbanization were evaluated. Consideration of additional problems including metals mining, uranium mining, grazing and highway construction was not possible due to limitations in the databases. (However, there are discussions addressing highway construction and grazing impacts on a statewide basis in the physical degradation report provided by the program, Program Report No 22A, Appendix D.)

Evaluation of the risk posed by physical degradation requires review of ecological risk data and three distribution maps (Maps 14 - 16). 'ne agriculture matrix and Map 16 indicate the highest potential environmental risk due to plowing and harvesting is in the Central Oklahoma/Texas Plains, Mississippi Alluvial Plain and Central Irregular Plains. The silviculture practices of clearcutting and conversion of lands to pine monoculture has a significant impact on the environment. The risk posed by those activities tends to be centered where timber production is the greatest in the South Central Plains, Boston Mountains, and Ouachita Mountains (Map 14).

Urbanization is also pervasive but it appears to be greatest in the Texas Blackland Prairies along the Interstate Highway 35 corridor which includes the cities of Austin, Dallas, Ft. Worth and San Antonio (Map 15).

Discussion of Ranking of Environmental Problems by Ecological Risk Index Values

The ranking of problems depicted in Table 2 is determined to a great extent by the magnitude of the potential area of impact for each problem. Specifically, the problems with the greatest areas of impact (application of pesticides, toxic air pollutants and physical degradation of terrestrial systems) rank high, while those with low areas of impact rank low. However, the degree of impact for specific problems also modifies the risk index value ranking. Pesticide application and air toxic discharges potentially impact up to 42 million acres within the five state area and are widespread across the Region, impacting nearly all ecoregions. However, the risk index value for application of pesticides is nearly double the risk index value for toxic air pollutants.

Overall it appears that the risk index value ranking is influenced most by area of impact, followed by degree of impact values and then degree of vulnerability values. This is due to the range in values, for each of these variables. The total area of impact values range from 12,000 acres (for airborne lead) to over 42 million acres (for toxic air pollutants), a difference in magnitude of approximately 3,500. This is modified by the area of ecoregion, which reduces the range from 0.01 percent of the Region impacted (for airborne lead) to greater than 11 percent of the Region (air toxics), a factor of approximately 1100. The total degree of impact values range from 3 to 29, a factor of approximately 10. The total degree of vulnerability values range from 10 to 23, a factor of 2.3. The result is that the range in risk index values between problems is primarily determined by area but it is modified by degree of impact and degree of vulnerability.

Discussion of Residual Ecological Risk Per Ecoregion

When all of the individual problems are viewed collectively (Table 1 and Map 17), the risk index values are greatest for the Mississippi Alluvial Plain, Western Gulf Coastal Plains, South Central Plains, Texas Blackland Prairies, and Central Irregular Plains of Oklahoma.

Each of these ecoregions has high risk index values because they are impacted by a variety of problems. The Central Irregular Plains are subject to ecological risk because of particulate matter releases, application of pesticides, CERCLA hazardous waste sites, industrial point source discharges, RCRA hazardous waste sites, to)dc air pollutants and physical degradation caused by agriculture. This ecoregion is also vulnerable because of the relatively high number of terrestrial endangered species per county.

The Western Gulf Coastal Plains has a high aggregate risk index value due to POTW discharges, RCRA waste sites, to)dc air pollutants, ozone and carbon mono@de releases, industrial point source discharges and physical degradation of wetlands.

The Mississippi Alluvial Plain has a high risk index value due to particulate matter releases, physical degradation of wetlands, application of pesticides, industrial point source discharges and

physical degradation of terrestrial systems due to agriculture and silviculture practices. This area also has a high vulnerability value for soil erosion.

The South Central Plains has a high aggregate risk index value due to physical degradation of terrestrial systems caused by silviculture and agriculture, physical degradation of wetlands, particulate releases and numerous moderate values for other problems. This area also has a high vulnerability value for soil erosion.

The Texas Blackland Prairies has a high ecological risk index value due to airborne lead, ozone discharges, toxic air pollutants, physical degradation of terrestrial systems caused by urbanization, RCRA hazardous waste sites, POTW discharges and numerous moderate values for other problems.

Discussion of Problems Not Evaluated by the Risk Index Methodology

It was not possible to evaluate two problems at this time using the risk index methodology because of limited information on estimated areas of impact per ecoregion. These problems are Other Ground Water Contamination and Underground Storage Tanks. The Underground Storage Tank program provided the workgroup with an estimate of 21,400 leaking tanks in the Region, each with an estimated zone of impact of approximately one surface acre. The problem is how to distribute these estimated zones of impact per ecoregion. Until more site specific information can be obtained from state or local data sources, it will not be possible to evaluate this problem using the current risk index method. Nevertheless, it is possible to estimate the ranking by comparing total estimated area of impact with other programs which have been ranked. The 21,400 total acreage value appears to place the underground storage tank problem within ranking of the problems with the lowest level of residual risk. This is evident when the total areas of impact for other low ranking problems are reviewed.
Specifically, airborne lead has an estimated cumulative impact zone of 12,000 acres, particulate matter has an estimated cumulative impact zone of 311,000 acres and CERCLA waste sites has an estimated cumulative impact zone of 151,000 acres. Since leaking underground storage tanks are not likely to have a greater degree of impact than CERCLA sites, ranking the underground storage tank problem below the CERCLA problem is reasonable.

The ground water contamination problem differs from the underground storage tank problem, for the program was not able to identify specific sites of contaminated groundwater that were causing a problem to non-human populations. However, the program did provide the workgroup with a report that identified areas where groundwater contamination, as currently defined, could impact non-human populations. The areas of potential impact are the areas with Karst geology, the Central Texas (Edwards) Plateau and the Ozark Highlands. The problem which prevents utilization of the risk index methodology is narrowing the zone of impact to areas which represent a realistic scope of the problem. This can likely be accomplished through accessing state and local databases. In terms of ranking this problem by category, it is not possible at this time. However, it is likely to fall into the lower half of the risk index value ranking when the data is eventually obtained.

Two other problems are not evaluated using the risk index methodology, primarily due to shortages of manpower. Comprehensive data sets were provided by the programs for Other Municipal Waste-sites and Other Industrial Waste-sites. Unfortunately, the workgroup member initially assigned to review and evaluate the material was unable to do so due to demanding program related assignments. The task was reassigned to two other individuals but they were also unable to complete the necessary data review due to demands placed upon them by their programs.

Finally, the task of reviewing the data was undertaken by a fourth individual who was not able to complete the data review and evaluation in time to be included in this report. Throughout this project all workgroup members were frequently placed in situations of competing priorities. In all of these situations, the comparative risk project had to take a back seat to program related responsibilities. It is only due to the dedicated efforts of the workgroup members that nearly all problems were fully evaluated.

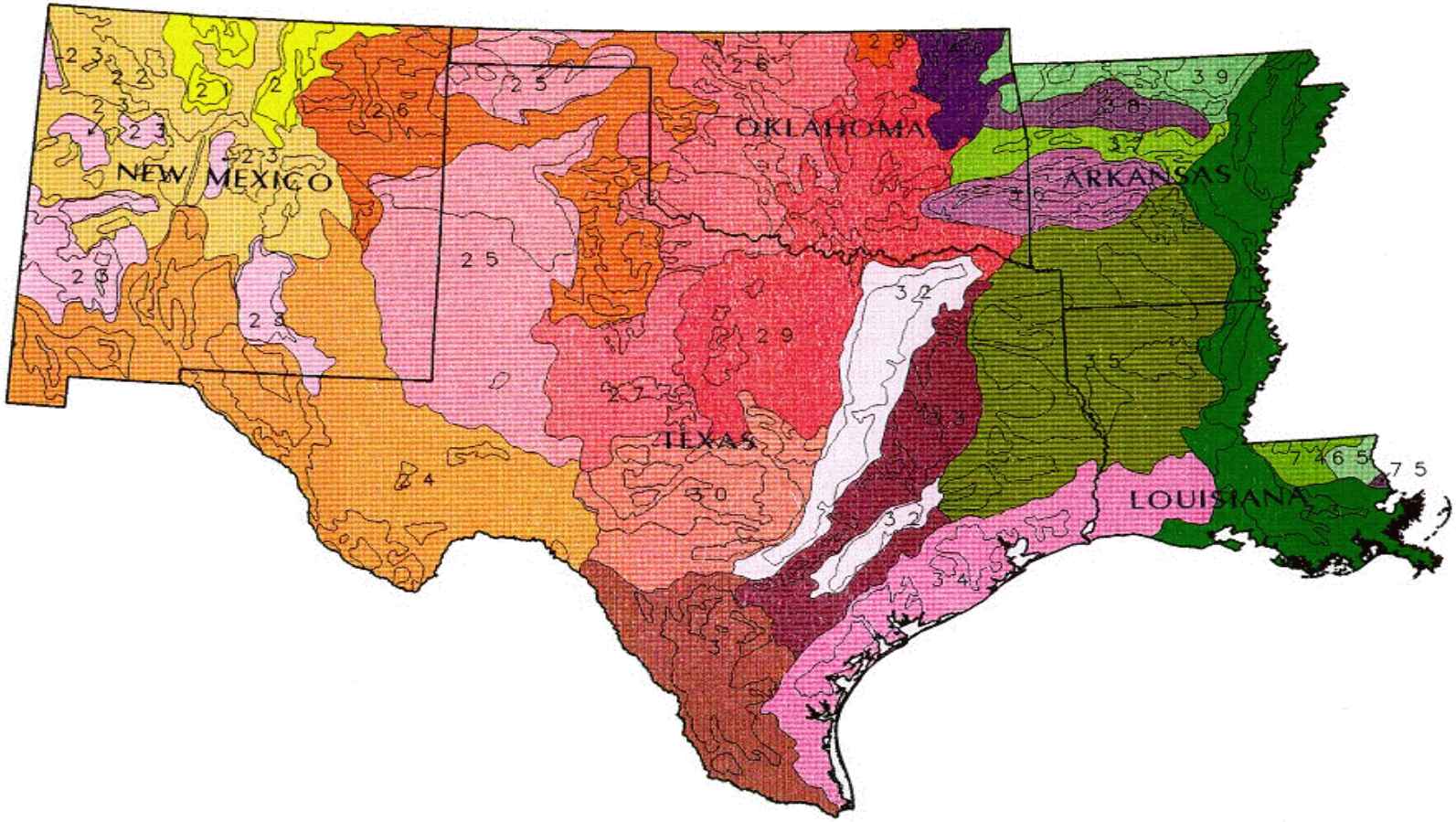
AP LEGEND

21) Southern Rockies, NM
22) Arizona/New Mexico Plateau
23) Arizona/New Mexico Mountains
24) Southern Deserts, NM/TX
25) Western High Plains, NM/TX
26) Southwestern Tablelands, OK/TX
27) Central Great Plains, OK/TX
28) Flint Hills, OK
29) Central Oklahoma/Texas Plains
30) Central Texas Plateau
31) Southern Texas Plains
32) Texas Blackland Prairies
33) East Central Texas Plains
34) Western Gulf Coastal Plains, LA/TX
35) South Central Plain, AR/LA/TX
36) Ouachita Mountains, AR/OK
37) Arkansas Valley, AR/OK
38) Boston Mountains, AR/OK
39) Ozark Highlands, AR/OK
40) Central Irregular Plains, OK
65) Southeastern Plains, LA
73) Mississippi Alluvial Plains, AR/LA
74) Mississippi Valley Loess Plains, LA
75) Southern Coastal Plains, LA

For further Description of each Ecoregion refer to ATTACHMENT B.

MAP 1

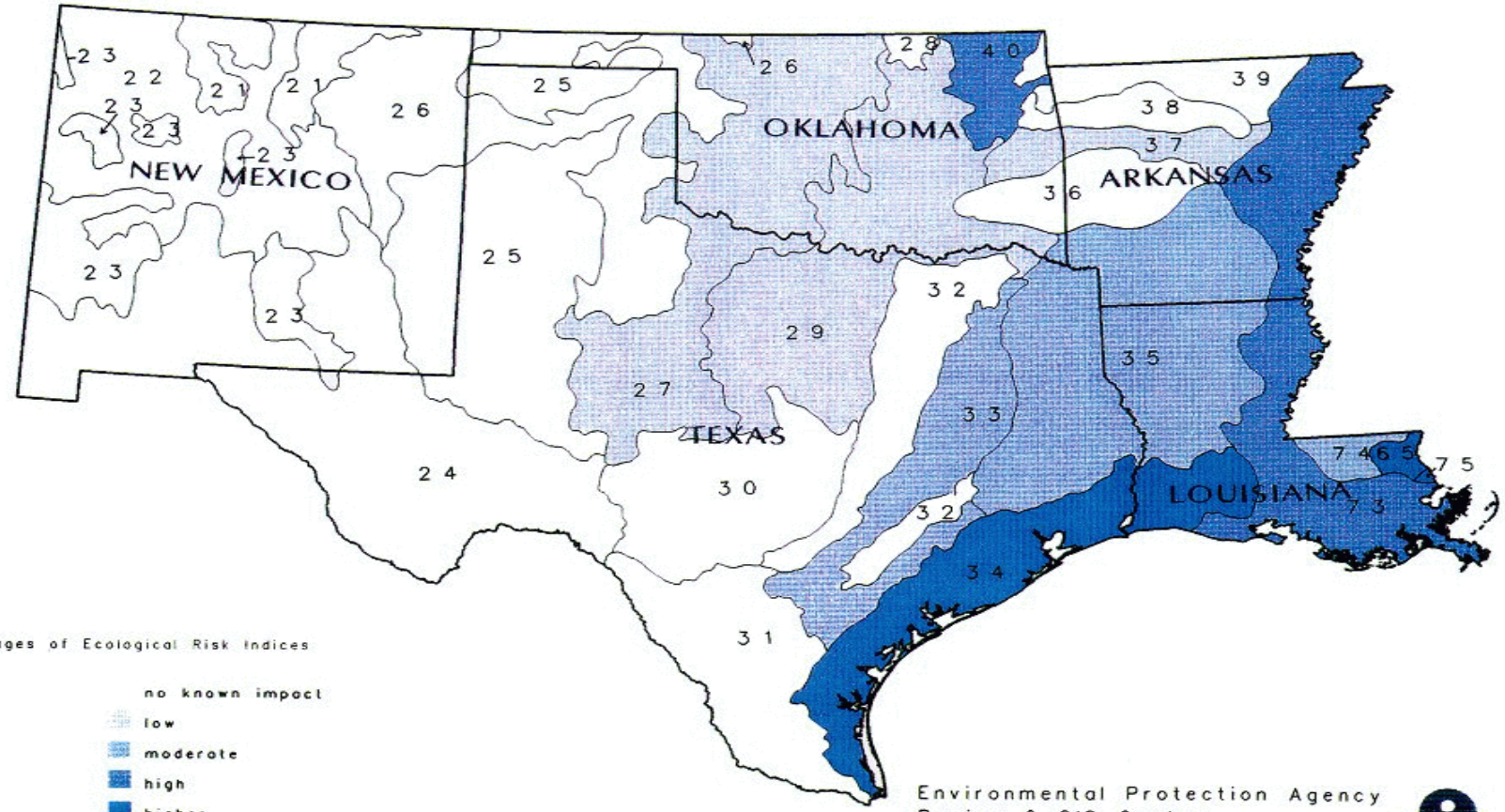
EPA Region 6 Ecoregions



MAP 2

Industrial Point Source Discharge

Distribution of Ecological Risk per Ecoregion



Ranges of Ecological Risk Indices

- no known impact
- low
- moderate
- high
- higher

Source: State 305(b) Reports

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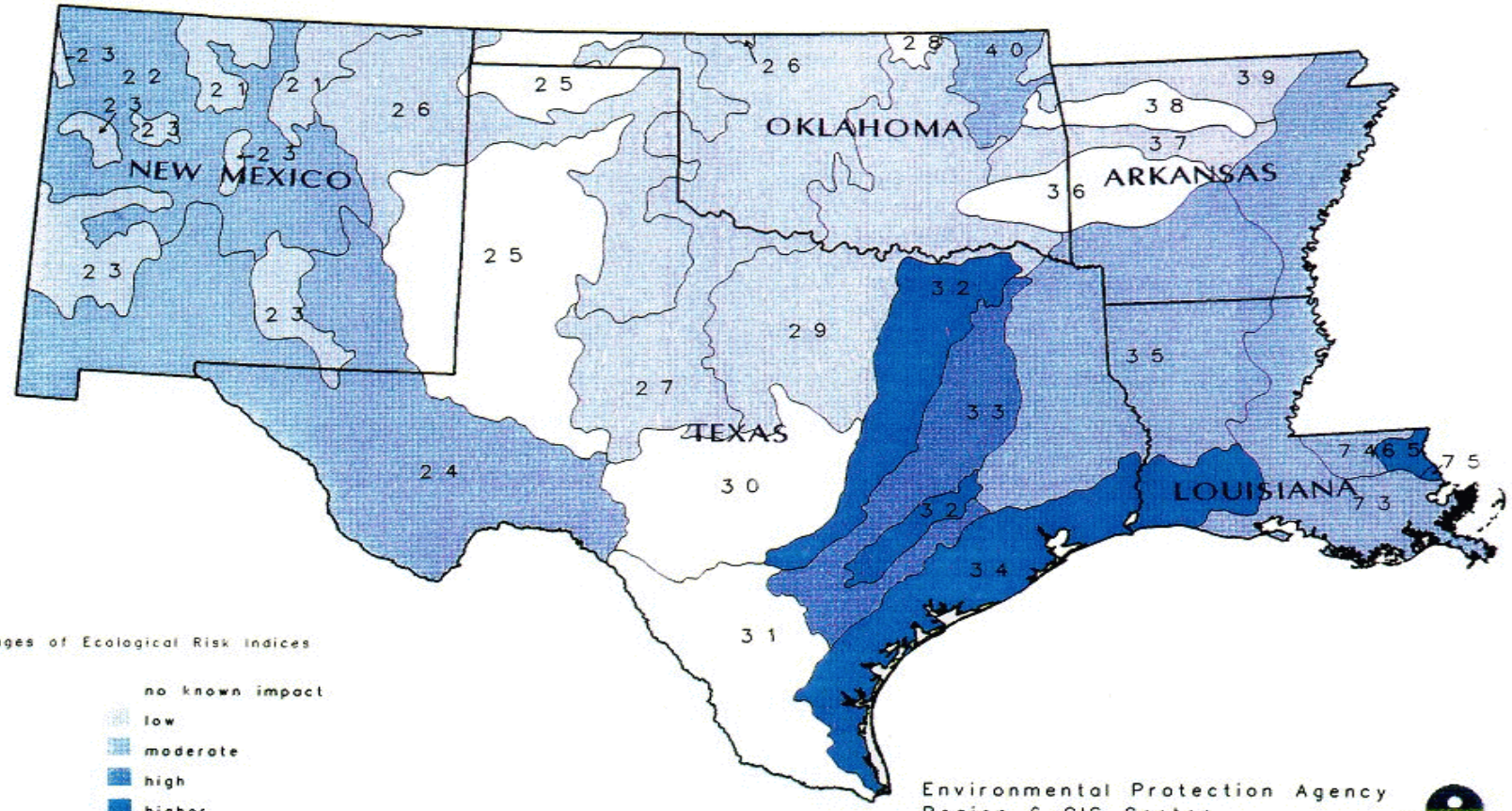
Dallas, TX

MAP 3

POTW Discharge

Distribution of Ecological Risk per Region



Ranges of Ecological Risk Indices

- no known impact
- low
- moderate
- high
- higher

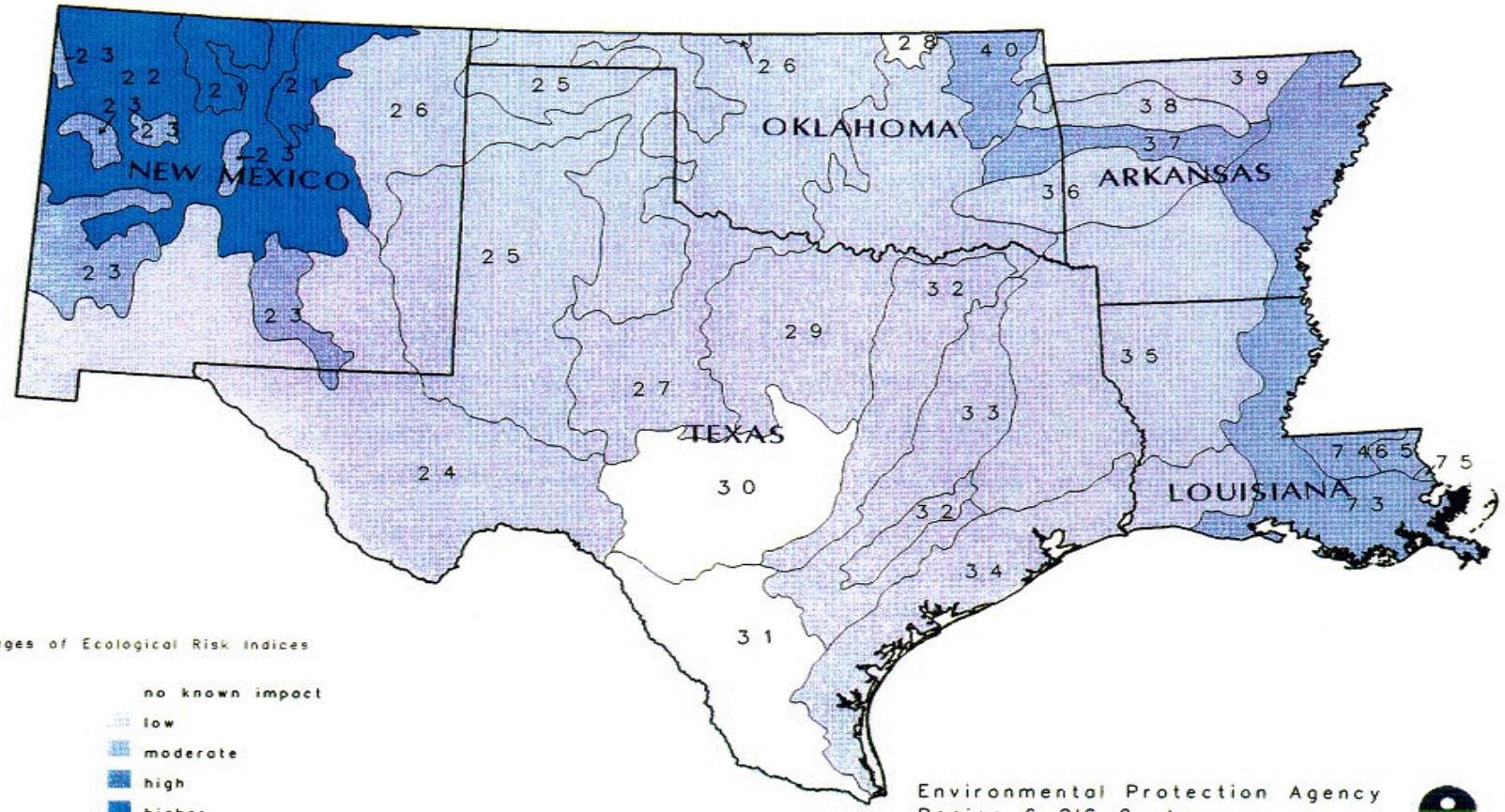
Source: State 305(b) Report

Environmental Protection Agency
Region 6 GIS Center
Dallas, TX

MAP 4

Non Point Source Discharges

Distribution of Ecological Risk per Ecoregion



Ranges of Ecological Risk Indices

- no known impact
- low
- moderate
- high
- higher

Source: State 305(b) and 319 Reports

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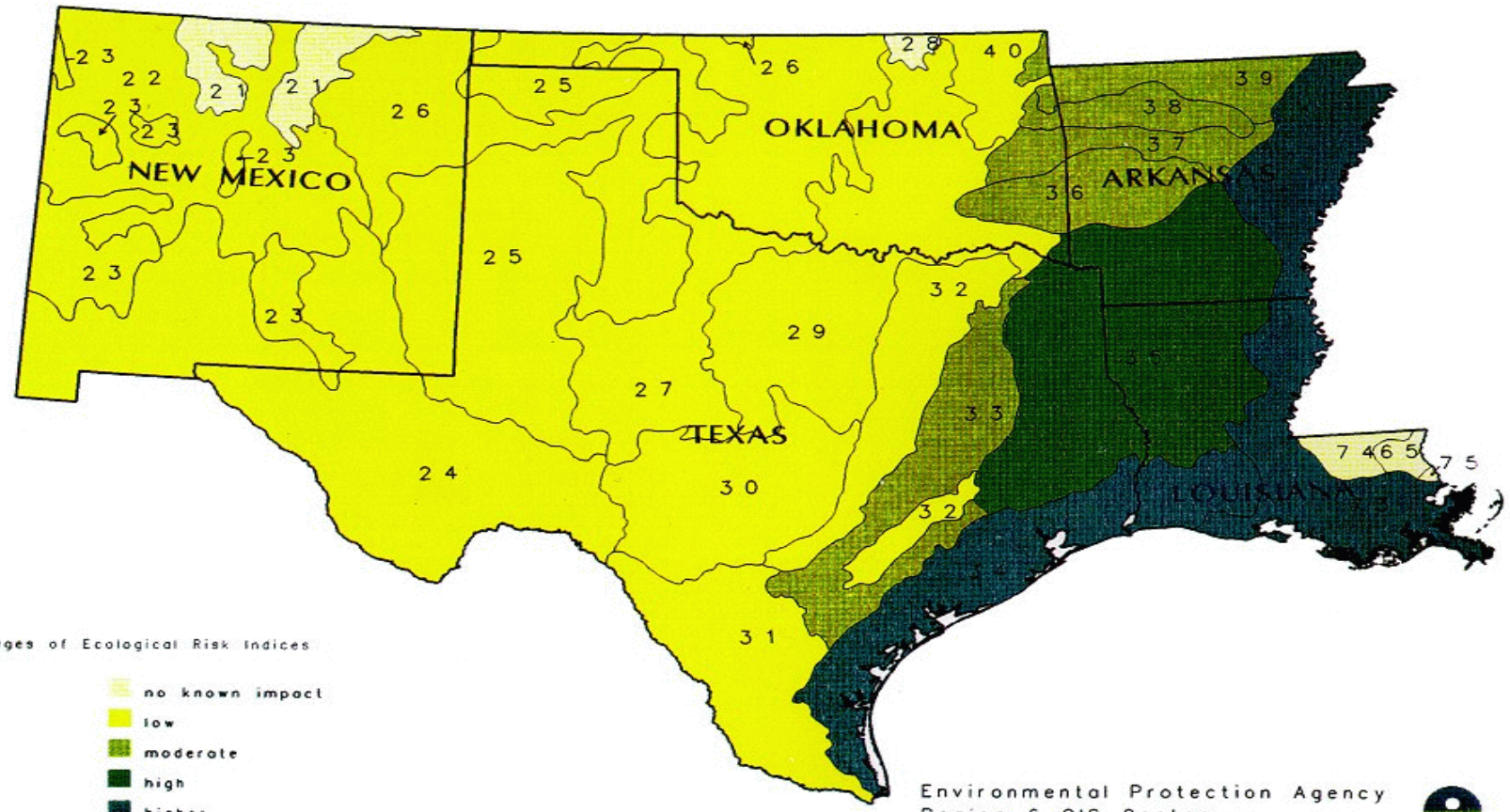
Dallas, TX

MAP 5

Water and Wetlands

Distribution of Ecological Risk per Ecoregion



Source: U.S. Fish and Wildlife Service

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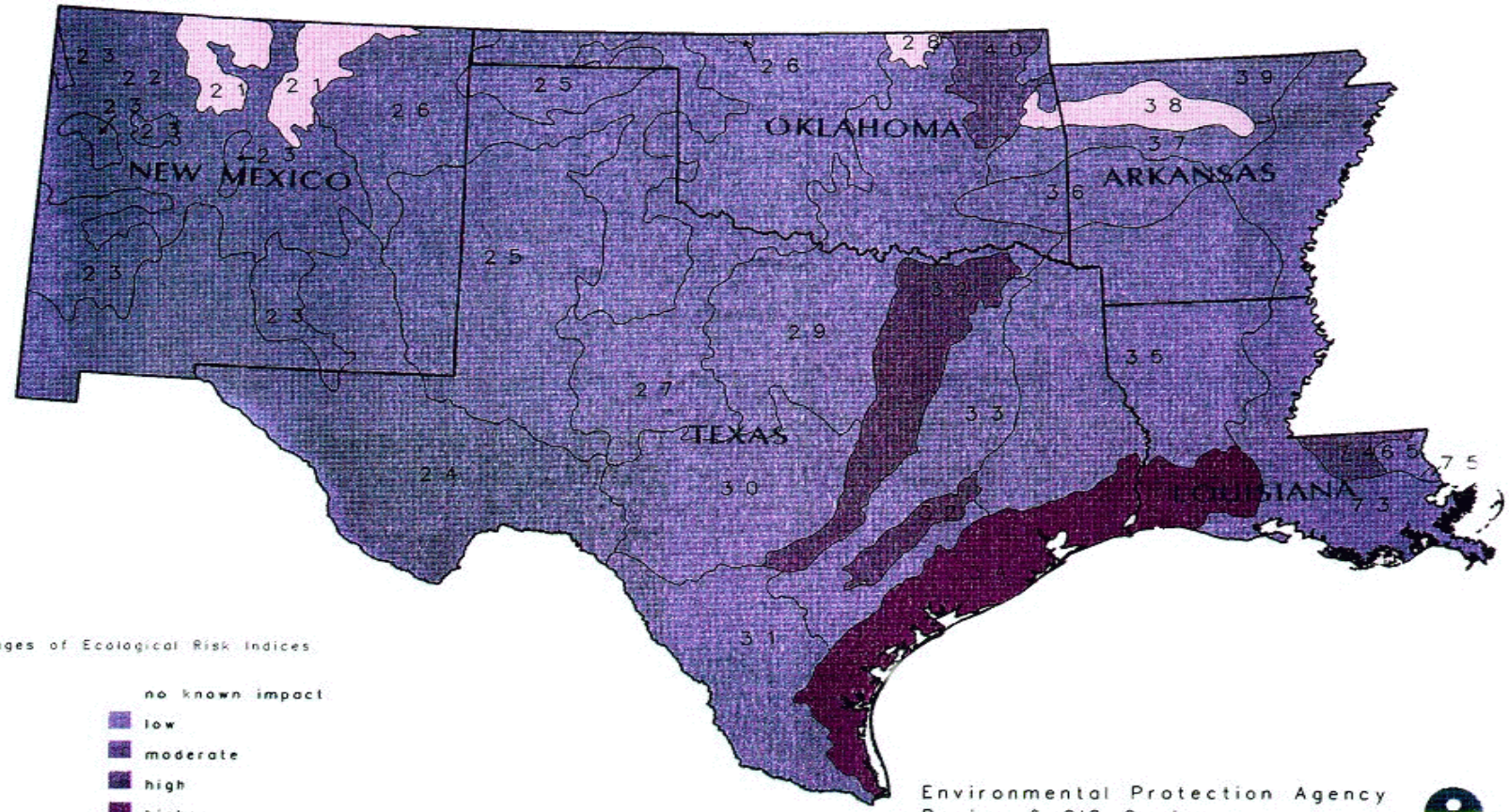
Region 6 GIS Center
Dallas, TX

MAP 6

RCRA Hazardous Waste Sites

Distribution of Ecological Risk per Ecoregion



Ranges of Ecological Risk Indices

- no known impact
- low
- moderate
- high
- higher

source: RCRA program

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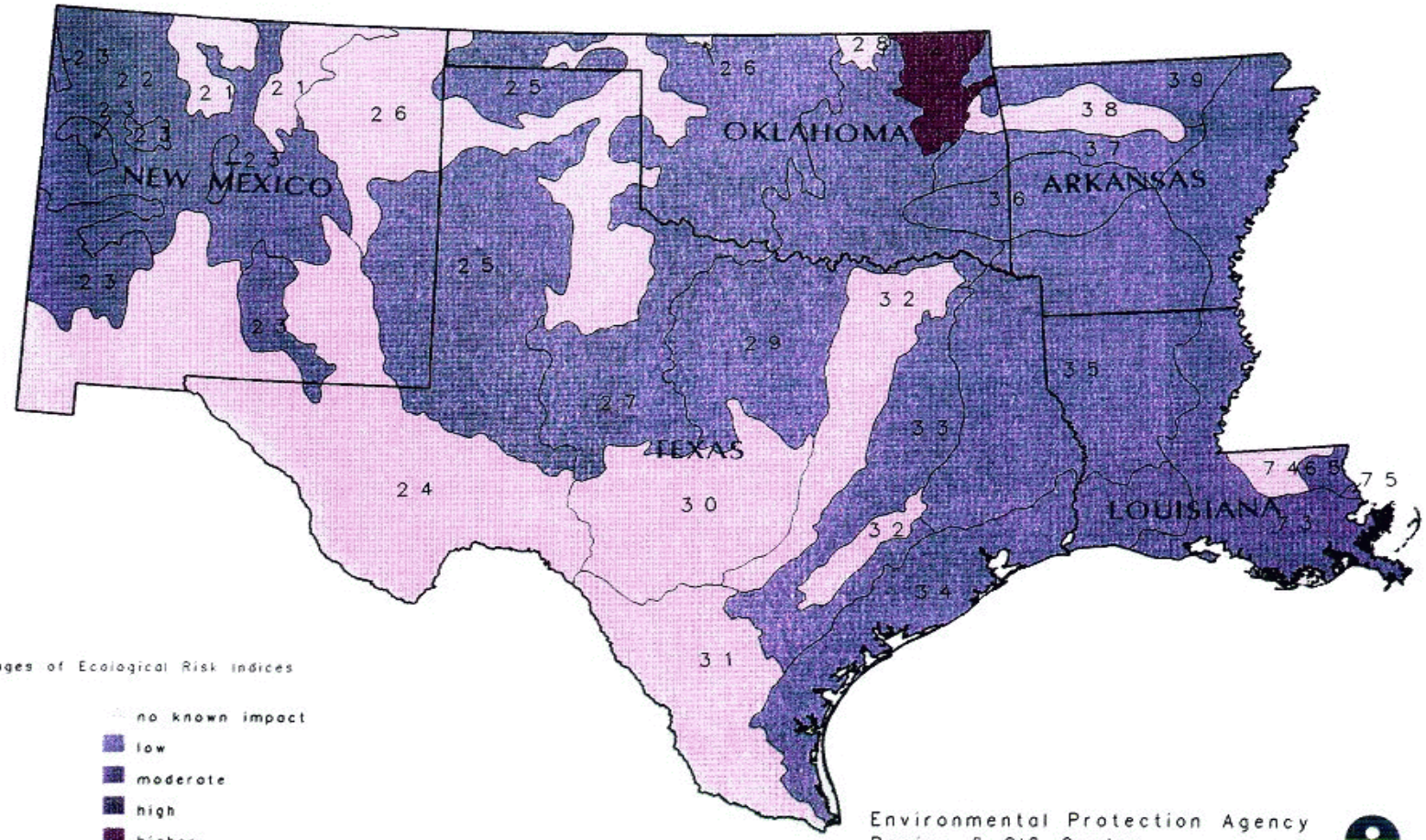
Dallas, TX

MAP 7

CERCLA Hazardous Waste Sites

Distribution of Ecological Risk per Ecoregion



Ranges of Ecological Risk Indices

- no known impact
- low
- moderate
- high
- higher

source: CERCLA program

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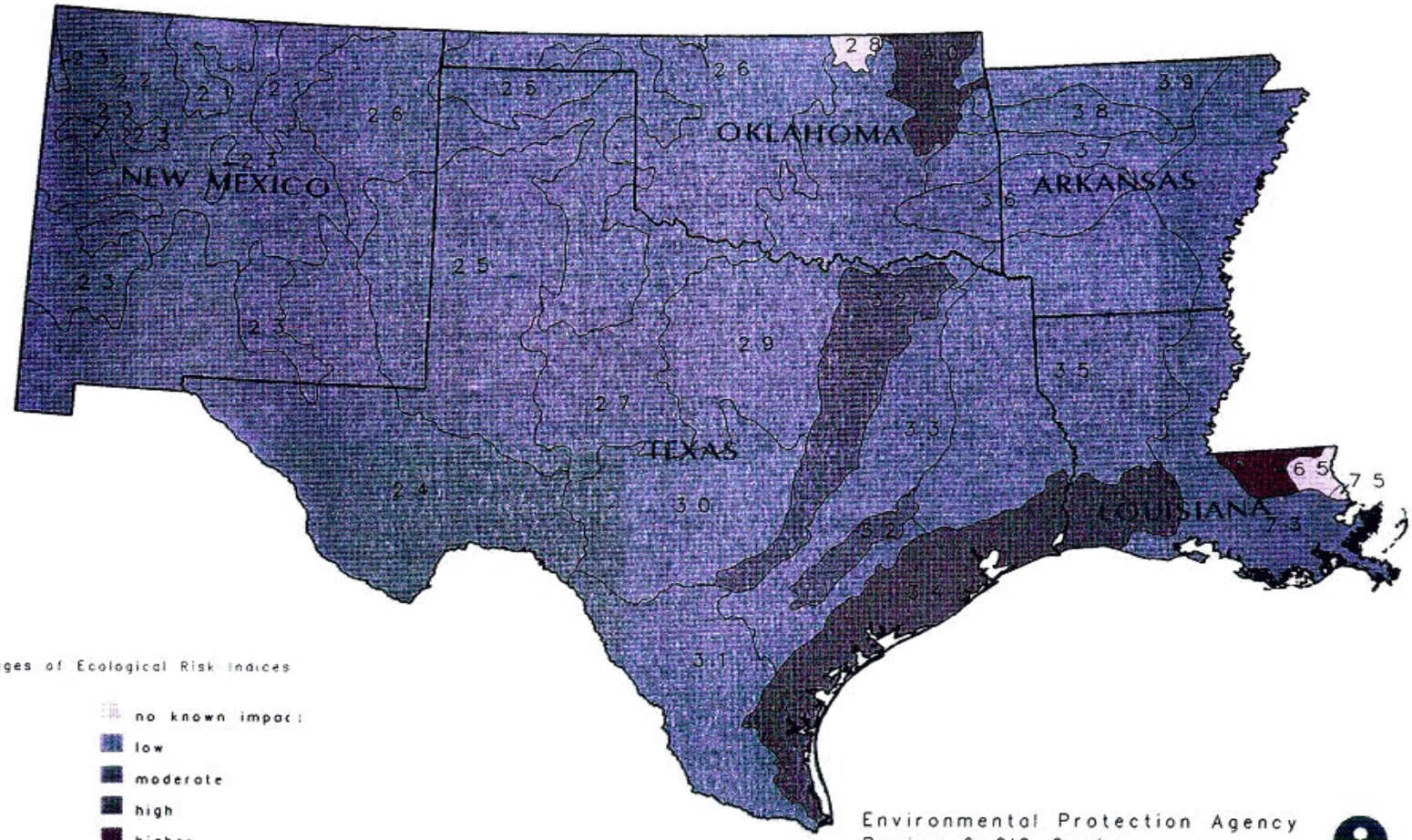
Dallas, TX

MAP 8

Accidental Releases

Distribution of Ecological Risk per Ecoregion



Ranges of Ecological Risk Indices

- no known impact
- low
- moderate
- high
- higher

source: U.S. EPA

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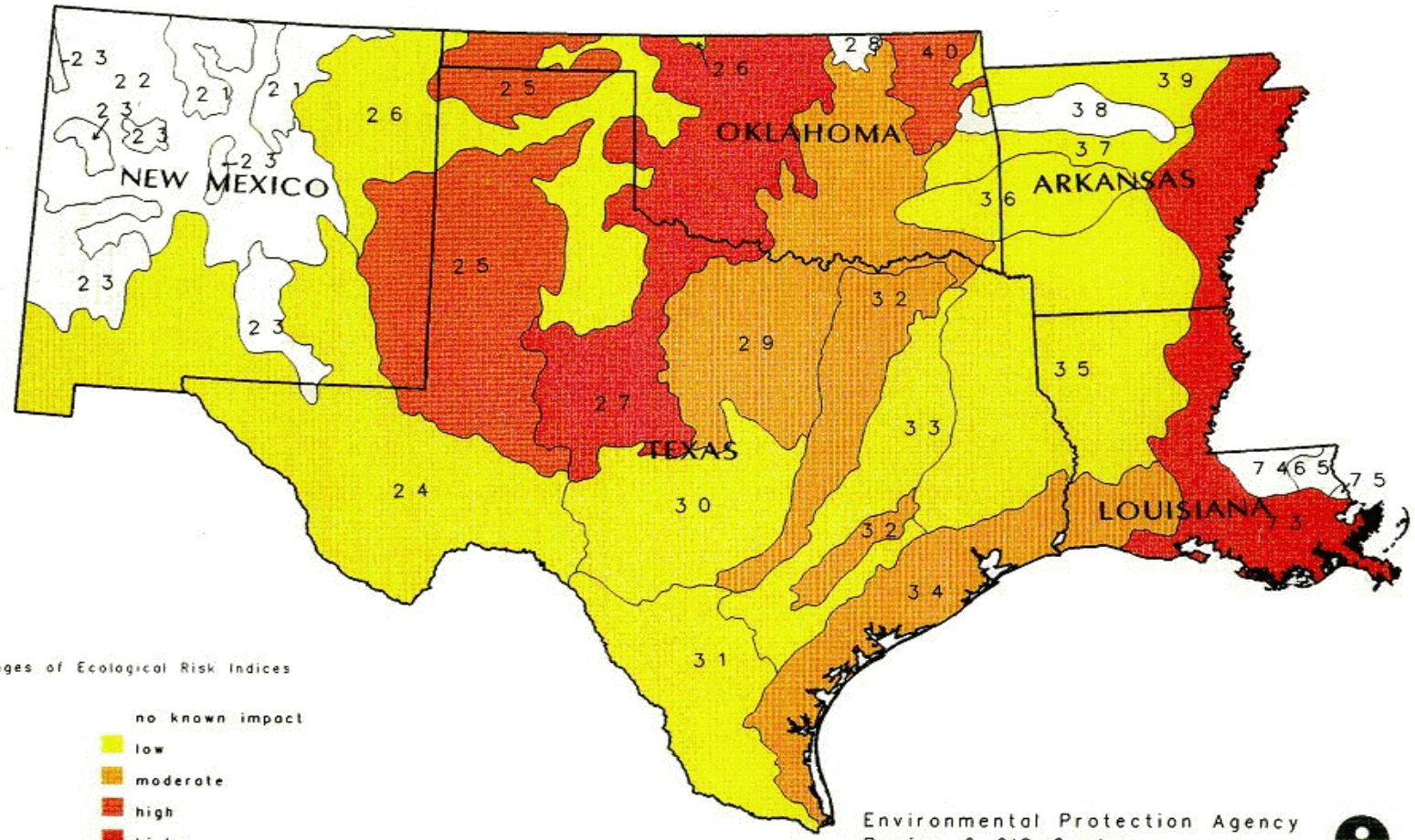
Dallas, TX

MAP 9

Application of Pesticides

Distribution of Ecological Risk per Ecoregion



Ranges of Ecological Risk Indices

- no known impact
- low
- moderate
- high
- higher

Source: State Agricultural Departments

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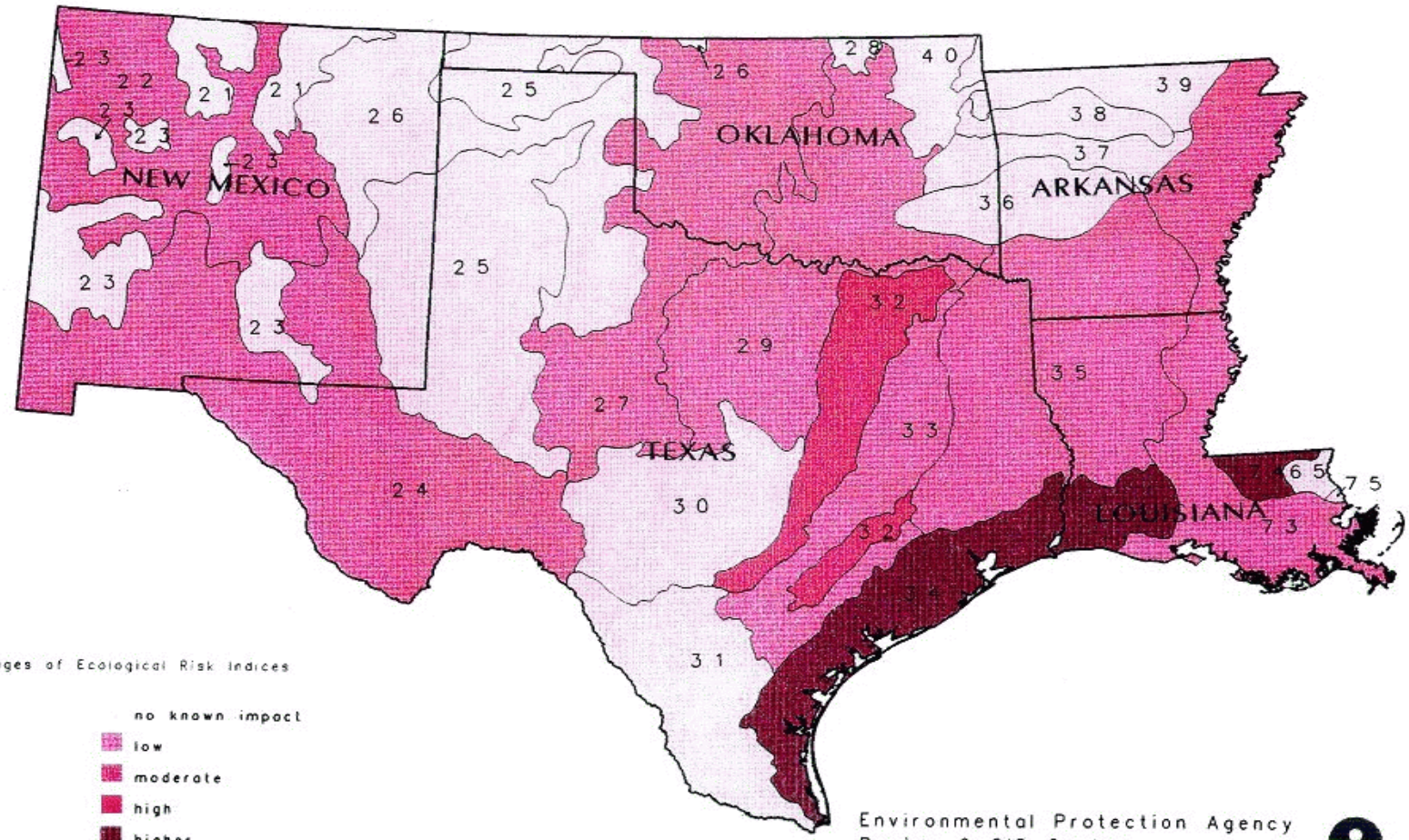
MAP 10

Ozone and CO

Distribution of Ecological Risk per Ecoregion



Ranges of Ecological Risk Indices

- no known impact
- low
- moderate
- high
- higher

source: U.S. EPA

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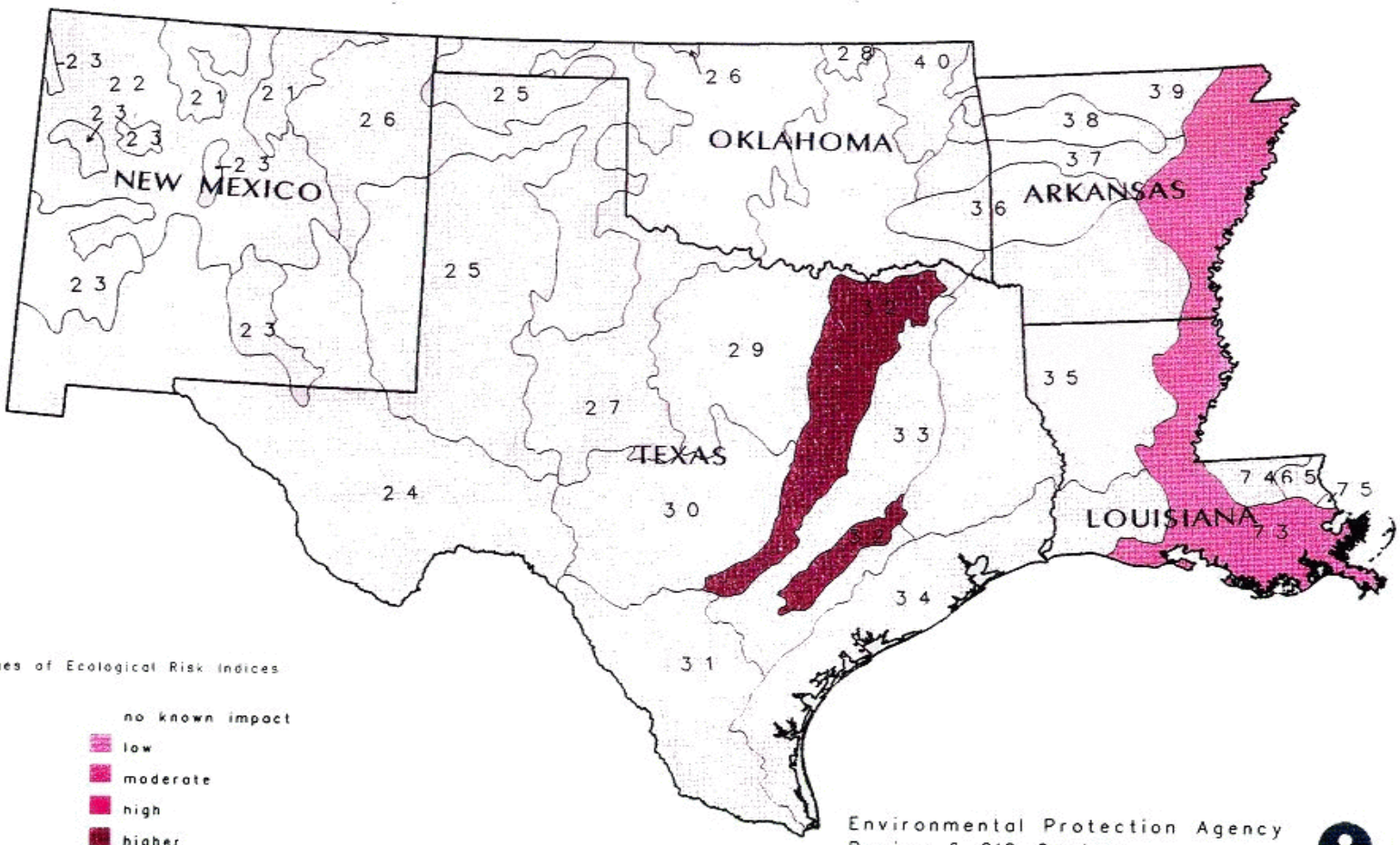
Region 6 GIS Center
Dallas, TX

MAP 11

Airborne Lead

Distribution of Ecological Risk per Ecoregion



Ranges of Ecological Risk Indices

- no known impact
- low
- moderate
- high
- higher

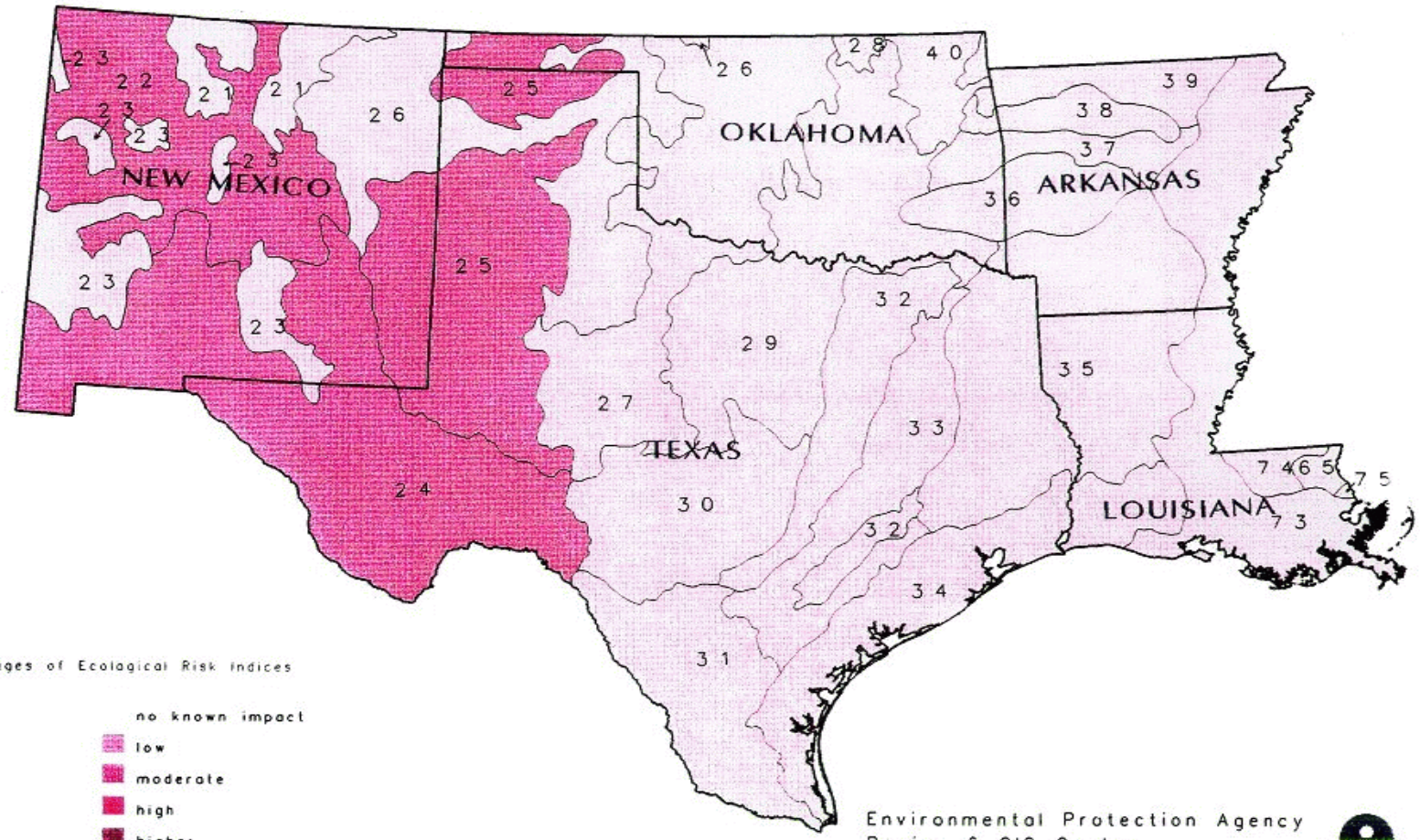
source: U.S EPA

Environmental Protection Agency
Region 6 GIS Center
Dallas, TX

MAP 12

Particulate Matter

Distribution of Ecological Risk per Ecoregion



Ranges of Ecological Risk Indices

- no known impact
- low
- moderate
- high
- higher

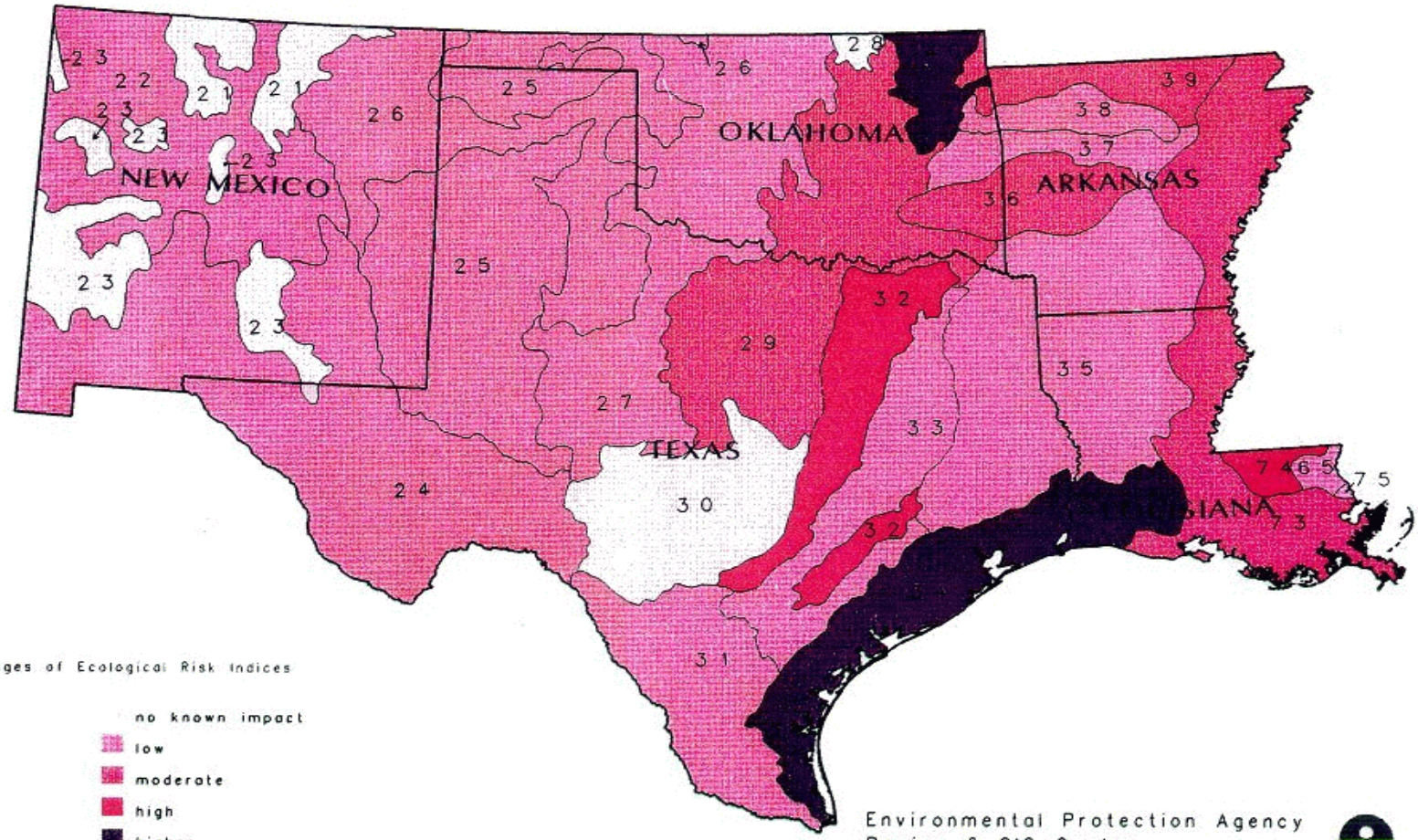
source: U.S. EPA

Environmental Protection Agency
Region 6 GIS Center
Dallas, TX

MAP 13

Toxic Air Pollutants

Distribution of Ecological Risk per Ecoregion



Ranges of Ecological Risk Indices

- no known impact
- low
- moderate
- high
- higher

source: U.S. EPA

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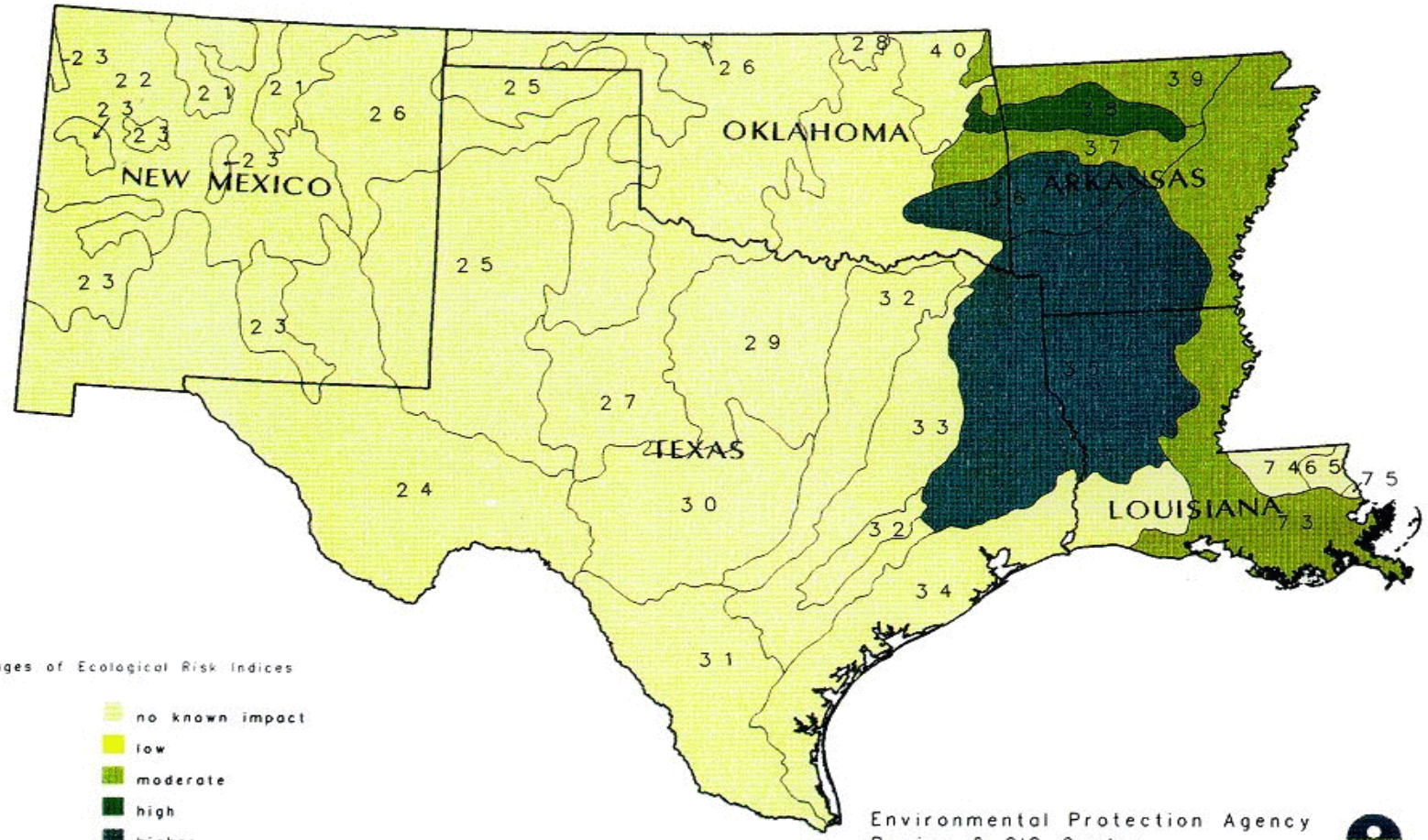
MAP 14

Physical Degradation - Silviculture

Distribution of Ecological Risk per Ecoregion



Ranges of Ecological Risk Indices

- no known impact
- low
- moderate
- high
- higher

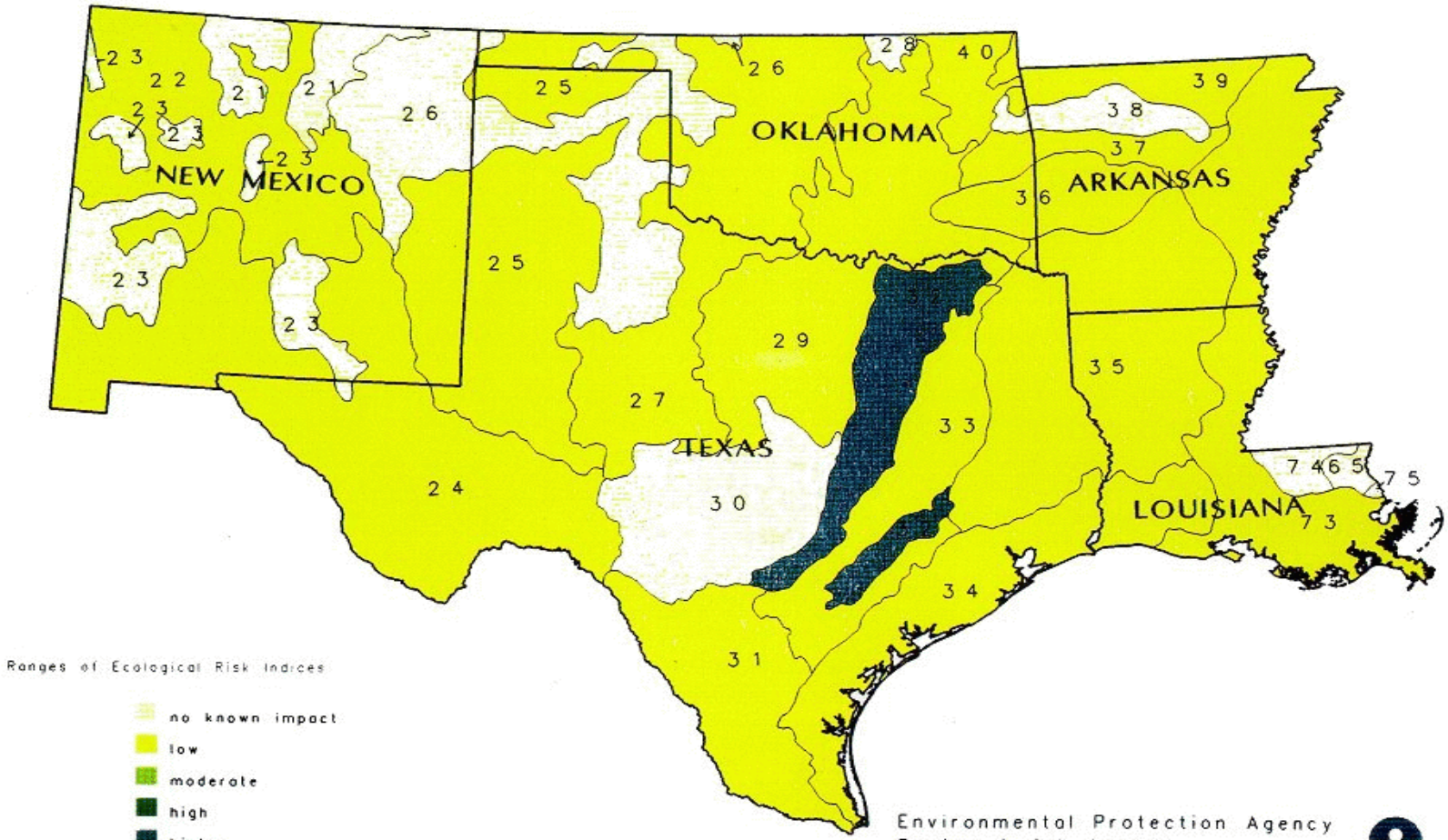
Source: U.S. Forest Service

Environmental Protection Agency
Region 6 GIS Center
Dallas, TX

MAP 15

Physical Degradation - Urbanization

Distribution of Ecological Risk per Ecoregion



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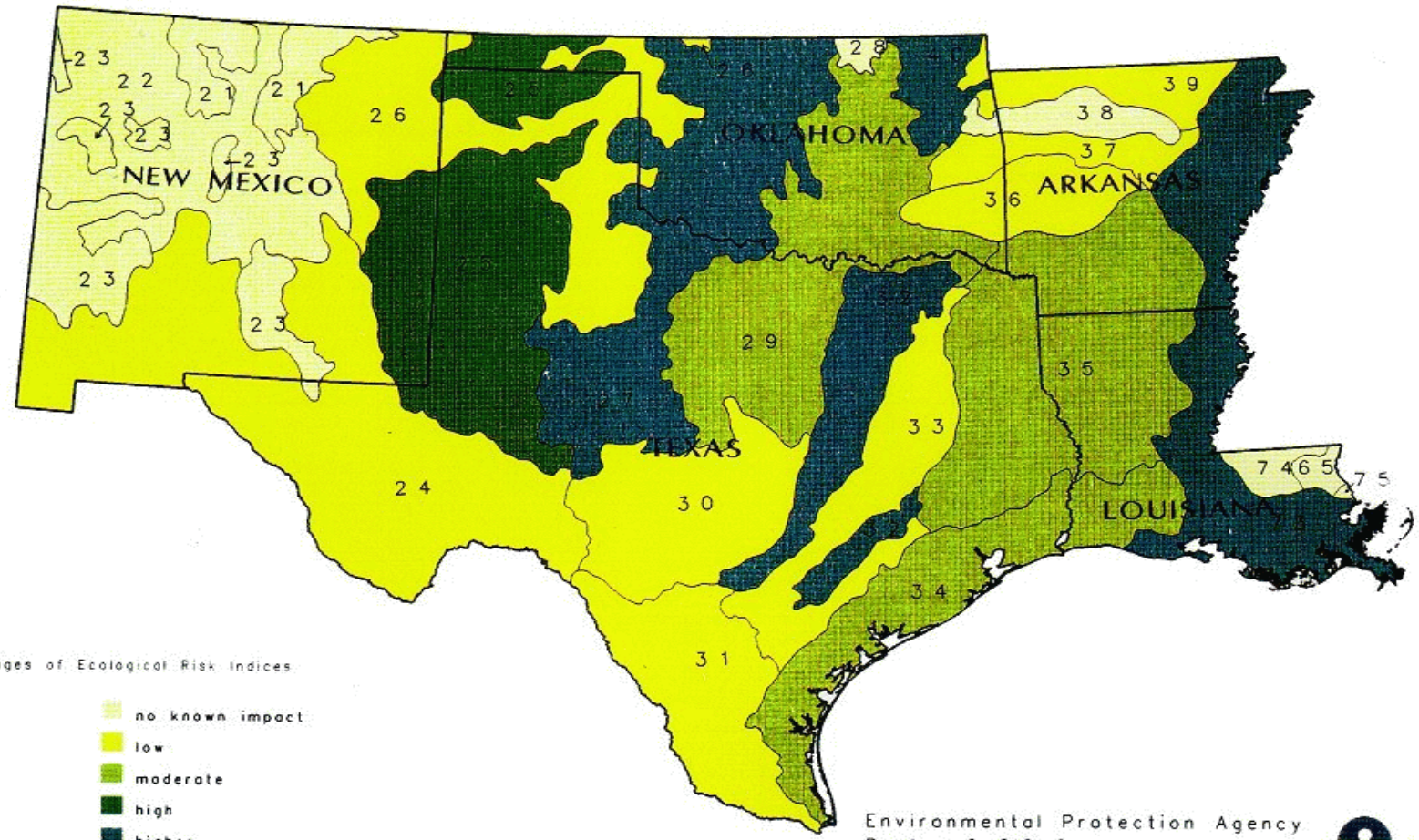
MAP 16

Physical Degradation - Agriculture

Distribution of Ecological Risk per Ecoregion



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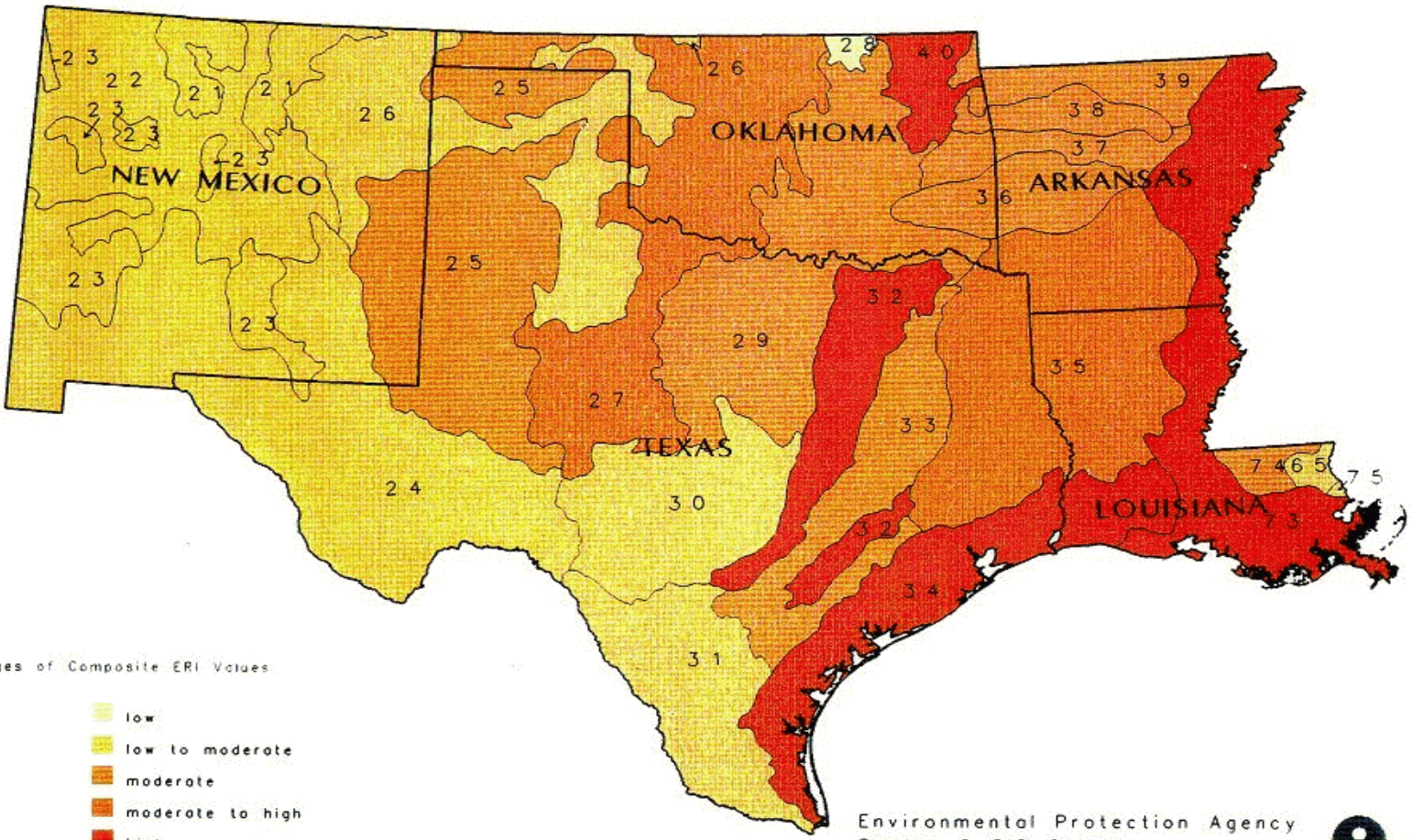
MAP 17

Ecoregional ERI Rankings

Distibution of Ecoregion's Ecological Risk



Ranges of Composite ERI Values

- low
- low to moderate
- moderate
- moderate to high
- high

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HUMAN HEALTH REPORT SUMMARY

The Human Health risk workgroup had the task of identifying and evaluating the carcinogenic and non-carcinogenic health risk posed by the 24 environmental problem areas being investigated by the Regional Comparative Risk Project (RCRP). The group developed a relative ranking of the risks associated with each of these problem areas based on both a quantitative and qualitative assessment of those risks.

The workgroup operated under three general ground rules. The rules were adopted by Region 1 and were used in the Region 6 project to provide consistency among the Regional projects. The first rule was that the Human Health workgroup assumed that the current levels of control and compliance remain in place, the residual risk posed by a problem area. The second rule was that current and future impacts from problem areas would be considered. Third, the workgroup considered average, not worst-case, exposures in each of the problem areas. The approach taken by the Region 6 Human Health risk workgroup was based on the methodology outlined in the national comparative risk project Unfinished Business. The approach used the standard components of risk assessment and is consistent with the general approach taken by Regions 1, 3, and 10.

Methodologies

Carcinogenicity Risk Evaluation

For each of the problem areas, where possible, a short list of chemicals was identified which represented the emissions associated with each problem. The indicator contaminants were selected based on how well the substances characterized a problem and on the availability of data. The workgroup relied upon Agency data and the individual expertise in the Region to identify the chemicals, pathways, and sources of critical data. The contaminants were then characterized as to their carcinogenic potency. EPA's cancer potency factors (Pf) were used.

The third step in the evaluation involved assessing the exposures posed in each problem area; estimates of the concentrations at which exposures occurred, the resulting contaminant doses, and the likely population exposed to the contaminants.

Sufficient data was not available for exposure assessments in all the problem areas. In these problem areas the workgroup modified the exposure assessments to optimize the available data (i.e., considering all residents served by a public water source as an “at risk” population if an MCL or reporting violation occurred within the water system serving those residents). This was necessary because data supporting the occurrence of known adverse health effects for these systems rarely exists.

The upper bound excess cancer risk was calculated with the equation:

$$\text{Risk} = (\text{Dose})\ (\text{Potency})\ (\text{Population})$$

In this equation if any component (variable) is zero, then the risk becomes zero and no risk exists.

The workgroup estimated the degree of uncertainty associated with the risk evaluations in each problem area. This uncertainty was described qualitatively as Low, Medium, or High (i.e., Low uncertainty meant the degree of confidence in the assessment was high). The basic criteria for the assessment of uncertainty included the availability and quality of 1) animal toxicological data for specific chemicals, 2) epidemiological data, 3) ambient and biological monitoring data, 4) medical or regulatory case study information, 5) the number of chemicals reviewed (coverage of problem area), and 6) the degree of extrapolation performed. Toxicological information was taken from Casarett and Doull's Toxicology, The Basic Science of Poisons and the National Library of Medicine's, Toxnet Database.

Non-Cancer Risk Evaluation

The non-cancer methodology followed the general approach as the cancer methodology. 'ne workgroup considered three variables in the determination. One was the population exposed. Another was the hazardous index (HI) estimation based on the severity of the health effects endpoint. The third was the potency of the contaminant based on the ratio of the concentration (ambient concentration) over the reference dose (RfD).

The data available to Region 6 was often in the form of exceedances of various ambient concentrations (air or water) or a monitoring or reporting violation. The workgroup was able to estimate the populations potentially impacted by such exceedances or other violation and scale these estimates from 1 to 4.

The Human Health workgroup used regional data to characterize the problem areas by criteria and scaling factors that were most appropriate. The severity, potency, population, and exposure evaluations were therefore combined to determine an estimate of the relative non-carcinogenic risk for each problem area.

The estimates of uncertainty were identical to that performed in the cancer evaluation methodology.

Upon completion of the carcinogenic and non-carcinogenic risk analyses, the workgroup organized problem areas with similar estimated risks into four categories relying on apparent “breaks” in the cancer and non-cancer calculated/estimated risks. Workgroup members agreed that further rankings within each category could be done based on acute or chronic threat and the degrees of uncertainty associated with the data.

The process for combining the carcinogenic and non-cancer rankings into a single “combined risk ranking” was a very subjective task. Regions 1 and 10 chose to categorize their combined risk areas, but did not rank them within each category. The Region 6 Human Health workgroup decided to follow this method. The subjective nature of combining cancer and non-cancer rankings and the realization that this would add separate degrees of uncertainty, convinced the

workgroup not to develop a single ordinal ranking of human health problem areas.

Results

Cancer Risk: The carcinogenic risk ranking for twenty-one of the twenty-four problem areas examined is presented in Table 3. The highest risk category (Category 1) includes Pesticides (application and dietary exposure), Radon, Indoor Air, and Stratospheric Ozone Depletion. Category 2: Hazardous /Toxic Air Pollutants, Drinking Water, and Radiation Other than Radon. Category 3: CERCLA Sites, RCRA Active Hazardous Waste Sites, Municipal Discharge to Surface Water, Industrial Discharge to Surface Water, Storage Tanks, Particulate Matter (PM_{10}), Non-Point Source Discharge, Aggregate Groundwater. Category 4: Municipal Waste Sites, Industrial Waste Sites, Airborne Lead, Ozone/Carbon Monoxide, SO_2 / NO_x, and Accidental Chemical Releases. A brief summary of the findings for the problem areas is presented in Attachment E.

Non-cancer Risk: Table 4 presents the non-cancer rankings. The highest risk, Category 1 includes Ozone/Carbon Monoxide and Drinking Water. Category 2: Pesticides, Airborne Lead, Particulate Matter (PM_{10}), Indoor Air, and Stratospheric Ozone Depletion. Category 3: SO_2 / NO_x, and Accidental Chemical Releases, Hazardous/Toxic Air Pollutants. The problem areas addressing physical degradation of water/wetlands and terrestrial ecosystems, and global warming were not ranked. These three were not thought to possess a significant non-cancer risk or the workgroup was not confident in estimating the future non-cancer risk. All other problem areas were ranked in the lowest risk category, Category 4. A brief summary of the non-cancer risk findings for each problem is presented in Attachment E.

Combined Health Risk: Table 5 combines the cancer and non-cancer risks from Tables 3 and 4. This process is very important to strategic planning, but proved to be quite subjective, carrying with it additive uncertainties. Category 1 combined health risk problem areas are Pesticides, Radon, Indoor Air Pollution, Ozone/Carbon Monoxide, and Stratospheric Ozone Depletion. Category 2: Drinking Water, Hazardous/Toxic Air Pollutants, Airborne Lead, and Radiation Other than Radon. Category 3: CERCLA Superfund Sites, RCRA Active Hazardous Waste Sites, Municipal Discharges to Surface Water, Industrial Discharges to Surface Water, so, / NO., Storage Tanks, Accidental Chemical Releases, Aggregate Groundwater Contamination, and Non-Point Source Discharges. All other problem areas were ranked in the lowest risk category, Category 4.

Physical Degradation of Water and Wetlands, Physical Degradation of Terrestrial Ecosystems, and Global Warming were not ranked.

Table 3. Health Risk Rankings
Carcinogenic Risk

	Problem Area	Estimated Incidence/Year
Category 1:	Pesticides	1475 to 2800
	Radon	(Group Range)
	Indoor Air	
	* Stratospheric Ozone Depletion	
Category 2:	Hazardous/Toxic Air Pollutants	240 to 260
	Drinking Water	(Group Range)
	Radiation other than Radon	
Category 3:	Superfund Sites (CERCLA)	6 to 70
	Active Hazardous Waste Sites (RCRA)	(Group Range)
	Municipal Discharge to Surface Water	
	Industrial Discharge to Surface Water	
	Storage Tanks	
	Particulate Matter (PM_{10})	
	Non-Point Source Discharge	
	Aggregate Groundwater	
Category 4:	Municipal Waste Sites	< 1
	Industrial Waste Sites	< 1
	Airborne Lead	< 1
	Ozone/Carbon Monoxide	< 1
	$S0_2$ /NO_x	< 1
	Accidental Chemical Releases	< 1
Problem Areas Not Ranked	Physical Degradation of Water and Wetlands	
	Physical Degradation of Terrestrial Ecosystems	
	*Global Warming	

* Problem areas with human health impacts likely to occur in the future.
Problem areas are not ranked within risk categories.

Table 4. Health Risk Rankings
Non-Carcinogenic Risk

	Problem Area
Category 1:	Ozone/Carbon Monoxide
	Drinking Water
Category 2:	Pesticides
	Airborne Lead
	Particulate Matter (PM_{10})
	Indoor Air
	* Stratospheric Ozone Depletion
Category 3:	$S0_2$ /NO_x
	Accidental Chemical Releases
	Hazardous/Toxic Air Pollutants
Category 4:	Superfund Sites (CERCLA)
	Active Hazardous Waste Sites (RCRA)
	Municipal Waste Sites
	Industrial Waste Sites
	Municipal Discharge to Surface Water
	Industrial Discharge to Surface Water
	Storage Tanks
	Radiation other than Radon
	Aggregate Groundwater
	Radon
	Non-Point Source Discharge
Problem Areas	Physical Degradation of Water and Wetlands
Not Ranked	Physical Degradation of Terrestrial Ecosystems
	*Global Warming

* Problem areas with human health impacts likely to occur in the future.
Problem areas are not ranked within risk categories.

Table 5. Health Risk Rankings
Combined Health Risk Ranking

	Problem Area
Category 1:	Pesticides
	Radon
	Indoor Air Pollution
	Ozone / Carbon Monoxide
	* Stratospheric Ozone Depletion
Category 2:	Drinking Water
	Hazardous/Toxic Air Pollutants
	Airborne Lead
	Radiation Other Than Radon
Category 3:	Superfund Sites (CERCLA)
	Active Hazardous Waste Sites (RCRA)
	Municipal Discharges to Surface Water
	Industrial Discharges to Surface Water
	$S0_2$ /NO_x
	Storage Tanks
	Particulate Matter (PM_{10})
	Accidental Chemical Releases
	Aggregate Ground Water
	Non - Point Source Discharges
Category 4:	Municipal Solid Waste Sites
	Industrial Solid Waste Sites
Problem Areas Not Ranked	Physical Degradation Of Water and Wetlands
	Physical Degradation of Terrestrial Ecosystems
	* Global Warming

* Problem areas with human health impacts likely to occur in the future.
Problem areas are not ranked within risk categories.

For more information refer to Attachment E - Human Health Summary: Program Reports

Conclusions

The Human Health workgroup had to find common ground upon which to compare and ultimately rank the twenty-one problem areas. This became very difficult in that different programs and media (air, land, and water) often had little in common from a regulatory data standpoint. Data bases were not compatible, nor were the problem area languages (MCL, NAAQS standards, restricted days, future vs. present/residual risks). Given these difficulties, workgroup members found that basic scientific approaches and adherence to the concepts provided by EPA risk assessment methodologies became the needed common ground. The Human Health workgroup believes that the rankings represent the risks in the Region. Changes in any category can occur provided additional data is supplied to the workgroup or it is decided a general methodology change is warranted.

The workgroup relied heavily upon program/staff input for several reasons. They are the most informed source for Regional assessments and their knowledge concerning specific risks should be the basis for comparative risk evaluations. The process also allows Region 6 managers to review risk perceptions and assessment methods, as well as comparing them to other program approaches.

There were several problem areas where there was a serious lack of data and/or where harder work is required to complete the analysis. The problem areas with a relatively small amount of available Region 6 health risk information were Municipal and Industrial Waste Sites, Storage Tanks, Sulfur Dioxide and Nitrogen Oxides, general information regarding the contamination of drinking water wells, and non-point source discharges. The workgroup believes that under-estimation of risk may have resulted in these problem areas.

Problem areas were ranked on the combined list based primarily on the estimated number of people at risk from, not exposed to a problem area. The Ozone/Carbon Monoxide problem area was placed in Category 1 because of the high number of people at risk, the documented health effects to humans at ambient concentrations, the availability of monitoring data, and the estimated severity of heart disease, asthma, bronchitis, and other respiratory illnesses. Problem areas placed in Category 4 were not considered to present significant relative risk based on the data available to the workgroup.

Double counting of estimate cancer incidence numbers occurred for Radon, Drinking Water, and Aggregated Groundwater. These programs included lung cancer numbers for radon volatilizing from drinking water. For Drinking Water and Aggregated Groundwater, these numbers represented the majority of their cancer incidence estimates. Double counting may also have occurred in the counting of contaminated drinking water wells for Storage Tanks, Drinking Water, Groundwater, Solid Waste Sites, and Pesticides. In the ranking process, excess cancer incidents associated with radon in water supplies were credited to the drinking water problem area, not both drinking water and ground water.

Ozone/Carbon Monoxide was the only problem area ranked in the highest risk category which did not have significant cancer incidence numbers. This problem area's risk assessment was

driven by the high number of exposed Region 6 residents that were estimated to be “at risk” (asthma, bronchitis, and heart disease patients). Monitored concentrations of ozone in the Region have. been shown to be at levels documented to cause adverse health effects to this sensitive population. Questions regarding this ranking allowed a detailed study of regional monitoring data to be performed (See Program Report No. 15D in Appendix D).

Global Warming was not ranked. Although potentially devastating ecological, economic, and welfare damages are sure to occur if the sea level rises and climatic changes begin, the workgroup did not feel confident in projecting the non-cancer results of this environmental problem.

Stratospheric Ozone Depletion however, had a single offending pollutant (UV-B radiation) known cancer effects (skin tumors), and specific non-cancer effects. The workgroup believed that these effects could be so great that they demanded inclusion in the study. Global Warming and Stratospheric Ozone Depletion are described in detail on pages 111 and 117 respectively.

Pesticides application ranked high on the combined risk ranking because of the large numbers of farm workers, applicators, and mixers in the Region who are directly exposed. There was some question by reviewers regarding the "occupational exposure' aspect of this problem area. EPA has regulatory responsibilities to the worker populations affected by pesticides. Therefore, the workgroup believed the assessment was within the problem area's definitional boundaries. If other programs were allowed to include occupational exposures by definition, they may have ranked higher (i.e., Accidental Chemical Releases).

The high risk categories of the Combined Health Risk Ranking (Table 5) is dominated by air media environmental problems. Toxic Release Inventory (TRI) data indicates that chemical releases to air are of more potential hazard than chemicals released to other media. For humans this is due to the general toxicology-pharmacokinetics of the air toxins, the route of exposure (airborne contaminants are easily transported) and the lungs are vulnerable to chemical exposure and absorption (lung tissue can quickly transport many organic chemicals into the blood stream). Hazardous/Air Toxics are also the major source of greenhouse gases (Global Warming), stratospheric ozone depleting chemicals, tropospheric ozone precursors, and other general toxicants (i.e., carbon monoxide, lead, primary irritants, asphyxiants, aromatics, aldehydes, and carcinogenic chemicals).

Discussion of Toxic Release inventory data and Region 6

The Toxic Release Inventory (TRI) database was one of the many environmental/regulatory information sources used by the Human Health Workgroup. To our surprise, TRI information became one of the more easily accessed and "risk oriented" of the data sources.

In 1986 Congress enacted Community Right-to-Know legislation as part of the Superfund Amendments and Reauthorization Act. The law required specific industries to report their annual emissions of potentially toxic substances. These reports supplied EPA with release information to all media (air, water, land); location data with longitude and latitude coordinates,

city, state, county, zip code; type of disposal (underground injection, stack emissions to air, storm water run off, landfill, releases to municipal treatment plants, and others). The five page reports submitted for each chemical offered regulators sixty-one fields of information per chemical. Over eighty-thousand reports were riled throughout the nation. The data has been analyzed for three reporting years. TRI data is currently available for 1987 and 1988.
Nineteen eighty-nine data will be released in mid 1991.

TRI data was not gathered exclusively for regulatory purposes. It was primarily assembled for release to the public. However, the data is being used for enforcement targeting, permitting, and in pollution prevention programs. Community right-to-know information is also very useful in comparative risk evaluations. It must be stressed that health effects conclusions can not be made from TRI release data.

Proper use of TRI data demands that users know and understand the following limitations of the information:

1. Toxic Release Inventory data is reported by the regulated industry (self-reporting).

2. TRI data is predominantly estimate data (industries were not required to submit documentation of monitoring or establish new monitoring programs).

3. Industries were required to report once a year (July 1); the total amount in pounds of releases for a selected set of chemicals.

4. Not all industries were required to report emissions:

    a. only industries in the manufacturing sector (standard industrial classification codes 20-39)
    b. only if the facility used greater than 10,000 pounds of a reportable chemical per year
    c. only if the company employed more than 10 people

It has been estimated that the total TRI reported releases of chemicals may only account for approximately one-fifteenth of actual environmental releases by industries. Nonetheless, TRI releases totaled 6,241,030,746 pounds in 1988. The total amounts reported, the percentages going to specific media, and the types of chemicals being released were of great interest to state and local governments, EPA, the public, and the regulated industries. This law has directly lead to the reductions in industry emissions, enactment of state laws in our Region, and a more open dialogue and working relationship between industry, EPA, and the public.

Some very valuable information regarding the possible risk to the ecology, human health, and economy of Region 6 can be obtained from analysis of TRI data. The Human Health Workgroup used the data to examine releases associated with specific problem areas, environmental media, locations, and specific chemicals. The workgroup used the data to compare EPA Regions, Region 6 states, counties, industries, and even cities.

Chemical Releases - TRI National Report

TRI was one of the few EPA databases which requires detailed reporting for a large number of chemicals (approximately 320 specific compounds and 20 chemical categories). EPA has published a summary report of TRI release information. This TRI National Report is the basis for the following review of industry chemical releases in Region 6.

Table 6 presents a summary of TRI data for the states in Region 6. 'ne Region's total TRI releases to the environment was 1,614,076,108 pounds. This represents approximately twenty-six percent of the total releases from all industries in the nation. Louisiana and Texas ranked number one and number two respectively when individual state totals are compared. Region 6 accounted for 15.77 percent of the nation's air releases, 46.89 percent of its discharges to water, 10.48 percent for on site disposal (within the property of the reporting facility), discharges to surface water was 68.10 percent of the national total, 7.99 percent to sewage treatment plants, and 11.75 percent of off-site transfers for disposal. Of particular interest in these numbers are the underground injection, surface water discharges, and the releases to air. Underground injection numbers are of interest because of the disproportionate use of that media by Region 6 compared to other Regions. The region also released a large amount of pollutants to surface waters and to sewage treatment facilities compared to other regions. The chemical industry was the source of 63% of all TRI discharges to surface water and 80% of underground injection nationally. Region 6 has a large number of chemical manufacturers. Regional releases to air could be considered relatively moderate (15.77% of the national total). A closer look at the data reveals that Texas and Louisiana were among the top four states in total air emissions. The air media is of special interest for several reasons:

1) The general lack of regulatory authority to limit toxic releases
2) Air is essentially abiotic
3) The toxic potential of the classes of chemicals released is high
4) The global problems of Stratospheric Ozone Depletion and Global Warming
5) Many hazardous / toxic air sources are precursors to ozone formation or contribute to carbon monoxide, airborne lead, or SO, - NO. contamination of air
6) Chemicals in air can be transformed into simpler compounds of equal or greater toxicity concern

Figures 3 and 4 graphically display TRI data from Table 6.

Chemical Classes

Toxicology is a study of the harmful effects of chemicals and the conditions from which these effects occur. The key part of this definition being the focus upon "conditions". Before toxicity can be established, exposure must occur at a required concentration, from a required form of the offending substance, and to an appropriate receptor biological system.

Table 6

1988 TRI DATA
(APRIL 1990)
REGION 6 ENVIRONMENTAL DISTRIBUTION OF RELEASES AND TRANSFERS

Rank	State	Total[a] (pound)	Air Emissions Percent	Surface Water Discharge Percent	On-site Land Disposal Percent	Underground Injection Percent	Public Sewage Transfers Percent	Off-site Transfers Percent
18	AR	72,272,458	64.76[b]	10.30	2.68	9.74	1.5	310.99
1	LA	741,206,814	17.95	21.23	0.27	57.11	0.48	2.95
47	NM	24,398,821	7.72	0.00	91.27	0.00	0.15	0.86
23	OK	51,720,309	60.13	0.70	3.46	12.28	0.82	22.60
2	TX	724,477,706	23.46	0.59	4.26	53.95	5.58	12.16
	National	6,241,030,746	38.90[c]	5.79	9.00	19.47	9.14	17.70
	Region VI	1,614,076,108	15.77[d]	46.89	10.48	68.10[e]	7.99	11.75

[a]Region 6 total releases accounted for 25.86 percent of the total releases for the nation.

[b]Percentage of total state emissions to specific media. (Arkansas industries released 64.76 percent of their total emissions to the air).

[c]U.S. industry released 38.90 percent of its total Tri emissions to the air.

[d]Region 6 accounted for 15.77 percent of the nation's TRI air emissions.

[e]Region 6 accounted for 68.10 percent of the nation's TRI underground injection releases.

Some chemicals clearly have more potential for toxicity than others and that potential often depends upon the media in which it exists. Each large category of chemicals will have general toxicities that have been documented. Many are primarily only toxic in high concentrations and during direct, acute exposure. Acids, bases, and salts are more associated with this type of toxicity. These compounds are not usually persistent in the environment (the chemical half-life of sodium hydroxide in air is approximately 13 seconds). Metals are very persistent in the environment. They tend to bioaccumulate and can effect man through ingestion of contaminated animal and plant matter. Metals can cause numerous acute and chronic illnesses. Lead is one of the few toxins that has been convincingly shown to be toxic at ambient (background) concentrations. Mercury is a compound that will continually cycle from air, to land, to water, maintaining its toxicity potential. Likewise environmentally released organics, halogenated organics (chlorine, bromine, fluorine containing carbon compounds), and non-metals (ammonia, nitrate compounds, phosphorus) all have toxicological characteristics highly dependent upon their presence in air, water, or soil. Figure 5 shows the different classifications of chemicals and the general amounts released to the various media defined in the TRI database.

Acids, bases, and salts were the TRI chemicals most often released to surface water, underground injection and sewage treatment facilities. The potential toxicity to humans given these "conditions" is relatively low. Permitted TRI surface water releases and underground injections do not lend themselves to acute exposure potential to large populations. The lack of biological persistence in water by acids and bases also limit their chronic exposure potential. Figure 6 illustrates the relative amounts of TRI chemicals released to each media by each Region 6 state. Note the very large total amounts to underground injection and surface water. **Therefore, a large amount of Region 6 TRI data releases are or low human health toxicity concern.** Relatively small amounts of organics were reported as releases to land or surface water. Amounts of organics released **to** sewage and off-site locations (for landfill or incineration) were more significant. Organic compounds tend to be of low solubility and vapor pressure. Therefore, a large portion of these pollutants will volatilize and ultimately become air toxics. Pollutants released from water and land to air are not always reported and may be underestimated.

TRI metals were primarily released to land, either on-site for land disposal or off-site to landfills or incineration. TRI data does not suggest that industry release of metals is a primary concern in the region. TRI releases of lead and compounds of lead to water is illustrated in Figure 7. The toxic potential from these releases to water are being evaluated at this time. From TRI information, Region 6 does not appear to release a substantial amount of lead compounds to water.

Comparative risk evaluations of specific compounds released to the Region's various media from industrial sources support the above analysis of TRI data. The Human Health workgroup did not receive data to indicate that releases of pollutants to land and water were as toxicologically significant as those to air.

This does not mean that the potential is not always present for significant exposure and toxicity. Ingestion as a route of exposure (intake of contaminated water or food) must always be guarded against. Very few pesticides and most agricultural uses of chemicals are not addressed by the

TRI database. TRI data therefore, does not allow us to sufficiently assess risk from agricultural non-point source pollution. It also will not supply sufficiently information to determine the extent of groundwater contamination from industrial or municipal landfills.

TRI Releases to Air

Releases of organics, halogenated-organics, and non-metals were primarily released to air. Surface water, underground injection, and sewage also were receivers for these pollutants. Off-site transfer data is difficult to analyze because the chemicals are often transferred to locations outside of the regional boundaries for disposal. Releases to air may pose significant present and future risk to human populations. It is useful to examine chemical specific toxicity data, location of releases, and relative amounts of emissions to address the comparative risk to human health in the five states.

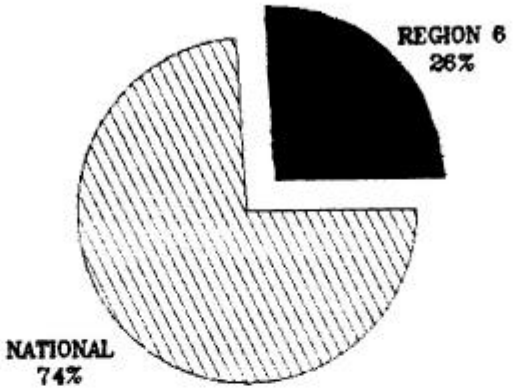
Many of the TRI chemicals released to air were neurotoxins. Figure 8 lists the top 25 TRI chemicals released to air. Nineteen of these chemicals are considered to have neurotoxicity potential. Populations particularly at risk include those with developing nervous systems (fetuses, newborns, and children) or those with declining nervous system (the elderly). Toxic effects possible from exposure to neurotoxins include impaired motor functions (movement, coordination), anxiety, confusion, memory loss, headache, dizziness, blurred vision, nausea, respiratory irritation, permanent lung damage (acute exposure), cancer, and death. Toxicological information from the National Library of Medicines Toxnet database regarding selected chemicals is presented in Attachment D. Health and environmental effects for the 25 chemicals with the largest TRI 1988 total releases to all media are presented in Table 7.

The pharmacokinetics of the chemical classes shown to be released to air in Figure 5 are such that absorption into the human body, translocation through cell membranes, and deposition into body tissues (i.e., fat, central nervous system, liver, and kidney) is considerably more possible than for chemicals released to the other media (land, water). Organic compounds are often much more lipid (fat) soluble than acids, bases, or salts. This is due to their non-polar chemical nature. Cell membranes of human cells are largely comprised of fatty acids, fats, cholesterol, and proteins. The general lipid characteristic of these membranes allow organic molecules to be more soluble in the membrane's chemistry. Therefore, these chemicals can be transported across cell membranes into the living cell or through them (absorption through lung tissue and capillary cells) into the blood stream.

Halogenated organic chemicals can be even more lipid soluble and thus at least equally as capable of gaining entry into the blood stream via inhalation. Once into the circulatory system these compounds more easily translocate from the blood to target organ tissues. The final pharmacokinetic factor to consider is that lipophilic (fat loving) chemicals which get into adipose tissue (body fat) will tend to stay for long periods, some for decades. This is partly because adipose tissue does not have a good blood supply (relative to most other tissues) and therefore organic and halogenated organic molecules essentially take up residence within the body and are only slowly released back to the blood stream (and eventually excreted).

Figures 3 and 4

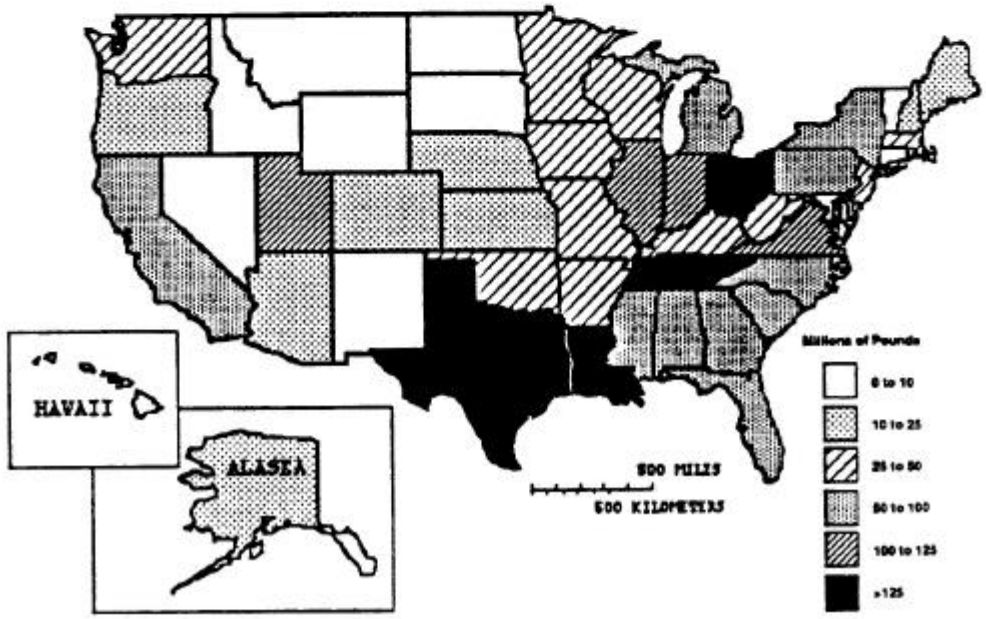
Region 6 Total TRI Releases
1988 TRI Data (August 1990)



TRI Chemical Emissions

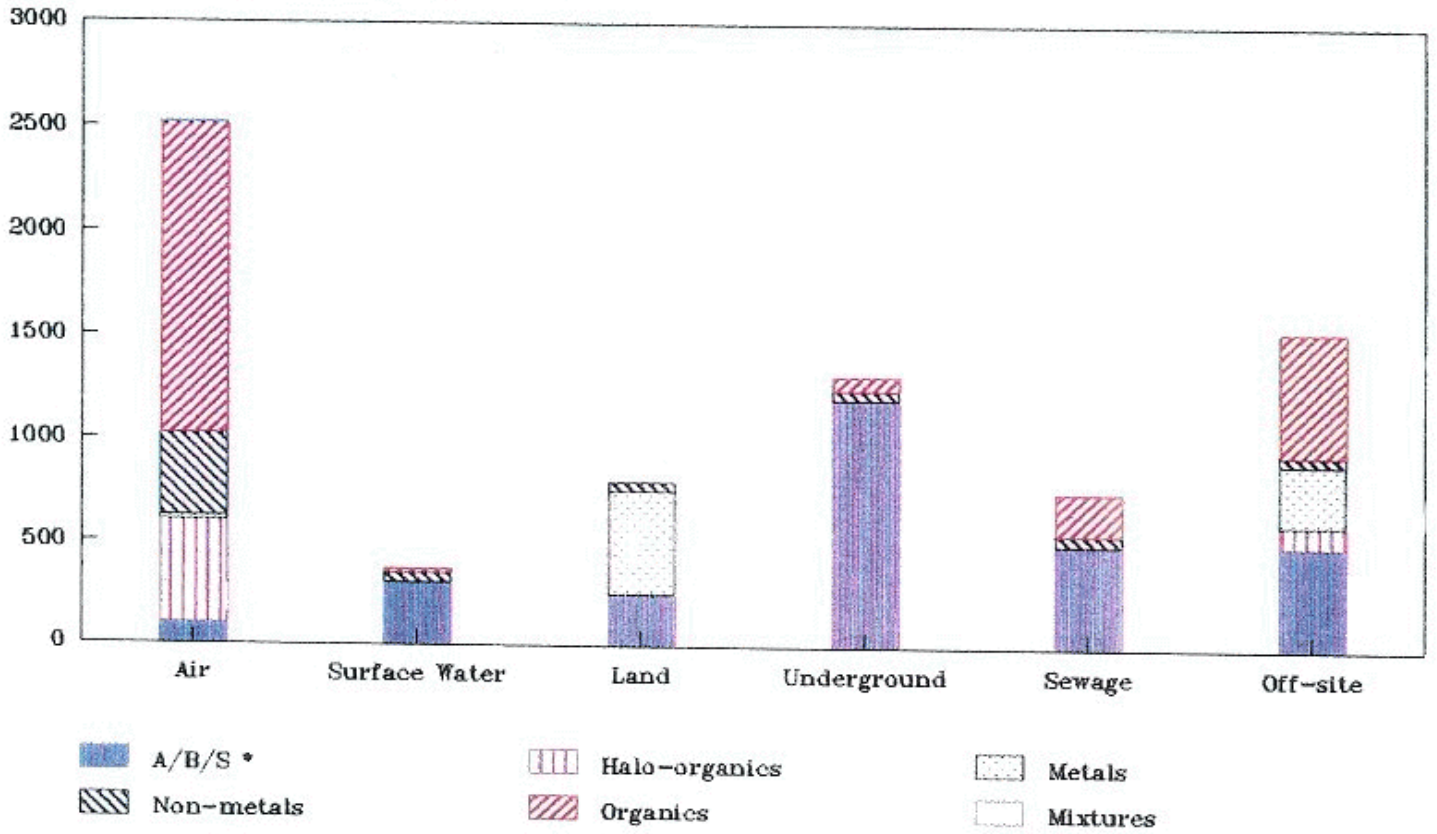
Source: TRI National Report, 1990.

TRI Total Air Emissions



Source: TRI NATIONAL REPORT; 1990

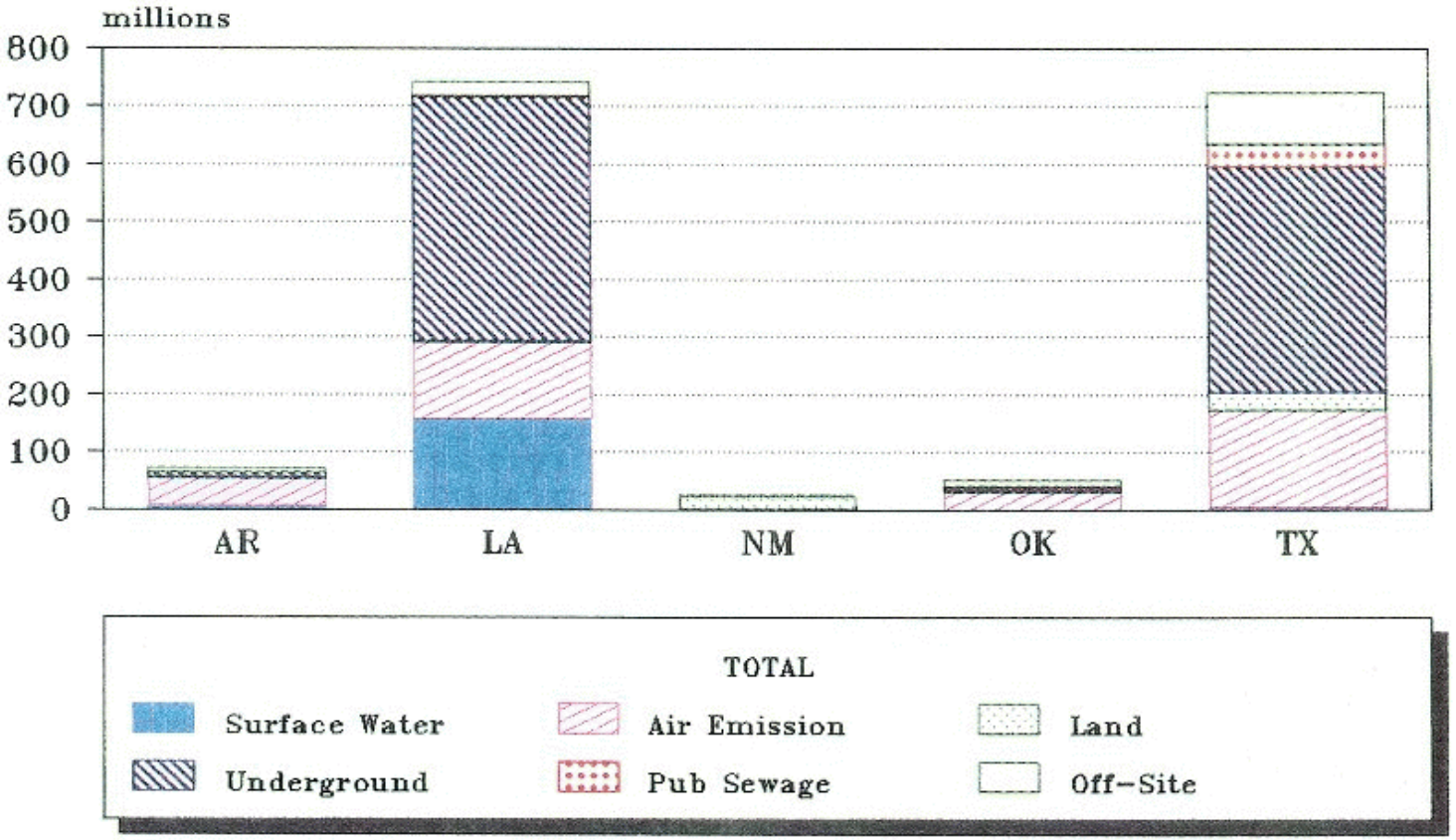
Environmental Distribution of TRI Releases and Transfers by Chemical Class



*A/B/S = Acids/Bases/Salts

Source: TRI National Report, 1990.

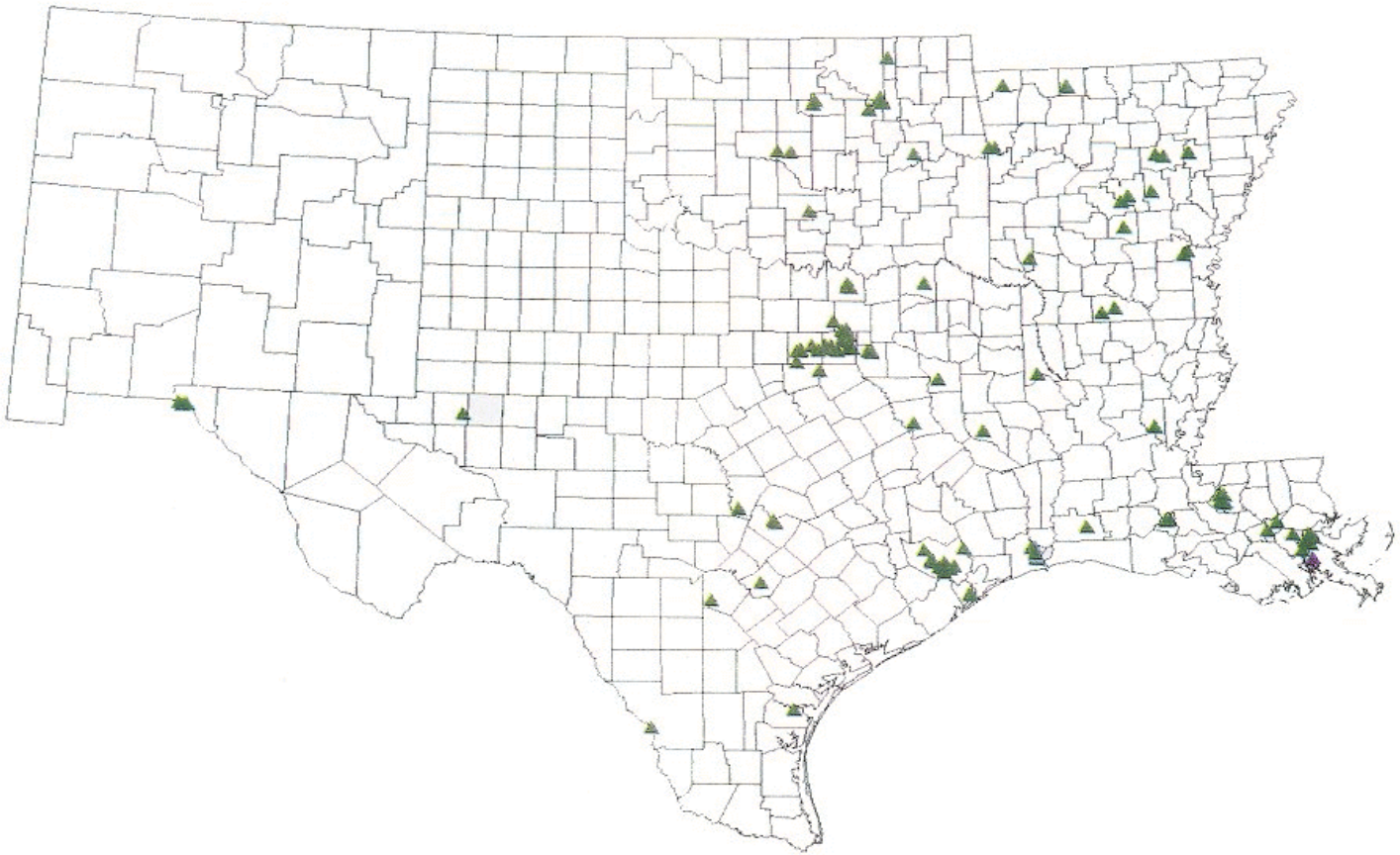
Region 6 Environmental Distribution
Releases/Transfers



Source: TRI National Report, 1990

Figure 7

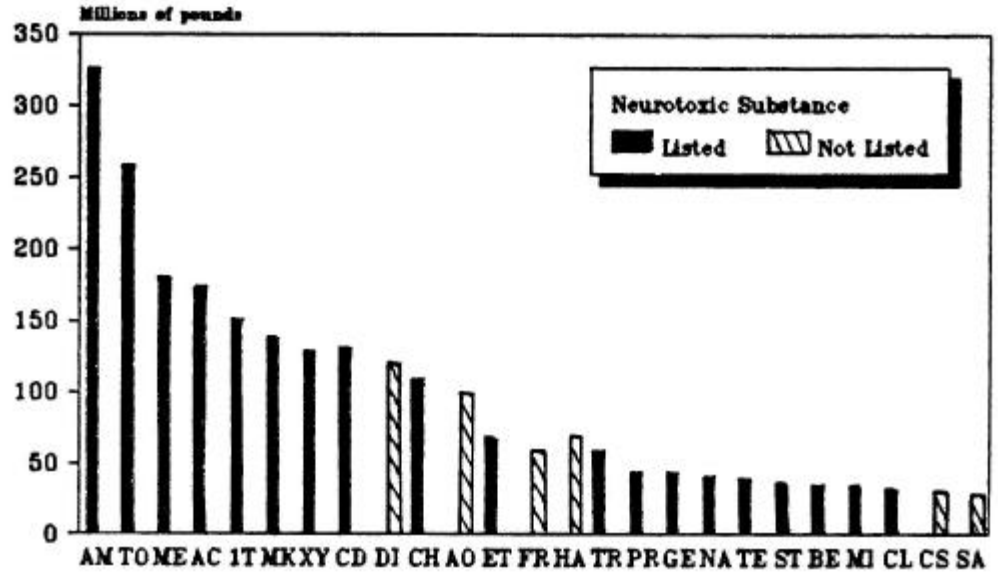
TRI DATA – WATER LEAD & LEAD COMPOUND EMISSIONS IN REGION 6



LEGEND: ▲ < 1,000 LBS ▲ < 10,000 LBS ▲ < 100,000 LBS ▲ < 500,000 LBS ▲ > 500,000 LBS

Figure 8

Neurotoxic Substances Among TRI's Top 25 Chemicals Emitted into the Air



AM–Ammonia	DI–Dichloromethane	NA–N–Butyl Alcohol
TO–Toluene	CH–Chlorine	TE–Tetrachloroethylene
ME–Methanol	AO–Aluminum Oxide	ST–Styrene
AC–Acetone	ET–Ethylene	BE–Benzene
1T–111–Tri–chloroethane	FR–Freon 113	MI–Methyl Isobutyl Ketone
MK–Methyl Ethyl Ketone	HA–Hydrochloric Acid	CL–Chloroform
XY–Xylene	TR–Trichloroethylene	CS–Carbonyl Sulfide
CD–Carbon Disulfide	PR–Propylene	SA–Sulfuric Acid
	GE–Glycol Ethers	

Source: Neurotoxicity, 1990

Table 7

Effects of the 25 Chemicals with the Largest TRI Total Releases and Transfers, 1988.

RANK	CHEMICAL	HEALTH AND ENVIRONMENTAL EFFECTS
1	AMMONIUM SULFATE	IRRITATION TO LUNGS, SKIN, AND MUCOUS MEMBRANES
2	HYDROCHLORIC ACID	IRRITATION TO LUNGS, EYES, AND SKIN
3	METHANOL	NERVOUS SYSTEM EFFECTS, BLINDNESS, RESPIRATORY PROBLEMS
4	SULFURIC ACID	IRRITATION TO LUNGS, EYES, AND SKIN
5	AMMONIA	IRRITATION TO LUNGS, EYES, AND SKIN
6	TOLUENE	NERVOUS SYSTEM EFFECT'S; IRRITATION TO NOSE AND EYES; CAN CONTRIBUTE TO SMOG FORMATION
7	ACETONE	LIVER AND KIDNEY EFFECTS; CAN CONTRIBUTE TO SMOG FORMATION
8	PHOSPHORIC ACID	IRRITATION TO LUNGS, EYES, AND SKIN
9	ZINC COMPOUNDS	EFFECTS VARY BY COMPOUND, INCLUDING NAUSEA, VOMITING, DAMAGE TO MUCOUS MEMBRANES
10	XYLENE (MIXED ISOMERS)	NOSE AND THROAT IRRITATION; EFFECTS ON NERVOUS SYSTEM, LIVER, KIDNEYS, SKIN, EYES AND BONE MARROW; BIRTH DEFECTS
11	1,1,1-TRICHLOROETHANE	LIVER, KIDNEY AND SKIN EFFECTS; CONTRIBUTES TO OZONE LAYER DAMAGE
12	METHYL ETHYLKETONE	NERVOUS SYSTEM EFFECTS; BIRTH DEFECTS; CAN CONTRIBUTE TO SMOG FORMATION
13	CHLORINE	IRRITATION TO LUNG, EYES, AND SKIN
14	DICHLOROMETHANE	LUNG CANCER AND LIVER CANCER
15	MANGANESE COMPOUNDS	EFFECTS VARY BY COMPOUND, INCLUDING EFFECTS ON THE NERVOUS AND PULMONARY SYSTEMS
16	AMMONIUM NITRATE	DIZZINESS, HEADACHE, VOMITING, CONVULSIONS, DEATH
17	CARBON DISULFIDE	NERVOUS SYSTEM, CARDIOVASCULAR, AND REPRODUCTIVE EFFECTS
18	NITRIC ACID	DENTAL EROSION, NOSE AND LUNG IRRITATION
19	FREON 113	CONTRIBUTES TO OZONE LAYER DAMAGE

Table 7

Effects of the 25 Chemicals with the Largest TRI Total Releases and Transfers, 1988.

RANK	CHEMICAL	HEALTH AND ENVIRONMENTAL EFFECTS
20	ZINC FUME OR DUST	IRRITATION TO LUNGS AND SKIN, FEVER, CHILLS, COUGH, NAUSEA, AND VOMITING
21	GLYCOL ETHERS	MALE AND FEMALE REPRODUCTIVE EFFECTS, BIRTH DEFECTS, IRRITATION TO LUNGS; CAN CONTRIBUTE TO SMOG FORMATION
22	ETHYLENE GLYCOL	BIRTH DEFECTS, LIVER AND KIDNEY EFFECTS; CON CONTRIBUTE TO SMOG FORMATION
23	COPPER COMPOUNDS	EFFECTS VARY BY COMPOUND, INCLUDING IRRITATION TO LUNGS, EYES, AND SKIN; EFFECTS ON NERVOUS SYSTEM AND KIDNEYS
24	TRICHLOROETHYLENE	EFFECTS ON THE NERVOUS SYSTEM, SKIN, LIVER, AND KIDNEYS; BIRTH DEFECTS; LUNG AND LIVER CANCER; CONTRIBUTE TO SMOG FORMATION
25	N-BUTYL ALCOHOL	EFFECT ON LIVER, SKIN, HEARING, BALANCE, AND RED BLOOD CELLS; CAN CONTRIBUTE TO SMOG FORMATION

The twenty-five carcinogens with the largest TRI releases, presented by release media, are listed in Table 8. Of these twenty-five, nineteen of them have the majority of their releases to air. Nationally fifty-three percent of TRI releases of carcinogens were to air (Figure 9). Region 6 ranked third among EPA regions in total pounds of chemicals released to air. This was 15.77 percent of the TRI air releases in the nation. Texas ranked number 1 nationally and Louisiana was forth. Air releases accounted for 23.72% of the Region's releases with Texas and Louisiana emitting 79.16 percent of the total pounds for the five states (Table 9).

Table 10 lists information concerning the Region's five states to include land area, total ,population, and total air TRI emissions, as well as population and chemical emission per square mile. Louisiana is shown to have the least area, the largest population per square mile, and the highest air emissions per square mile of our five Region 6 states. Arkansas and Oklahoma released over 60 percent of their TRI reported emissions to air. Texas, Louisiana and New Mexico were 23, 18, and 8 percent respectively. Figure 10 illustrates the region's air emission density (pounds per square mile) for each state (data from Table 10). Louisiana released more than 2,700 pounds of air emissions per square mile in 1988. Arkansas was second highest with approximately 880 pounds/sq. mile. Texas was third with approximately 600 pounds/sq. mile-

Also from Table 10, population density information shows Louisiana with 93 residents per square mile. A calculation of air emissions per person gives Louisiana the highest ratio at thirty pounds per person. This type of calculation can be very misleading. For example, the ratio of air releases per square mile to population per square mile for Texas yields a value of approximately 10 pounds of air toxic release per person. Figure 11 illustrates that Texas air -,emissions are greater than any other state's, but also with a much larger population. Air emissions in Texas are centered in industrialized areas along the Gulf Coast and in the Central and North Central parts of the state. Approximately ninety percent of the Texas population is in these areas, and so are the emissions to air. Therefore, there may be many more people in areas with high chemical emissions to air in Texas. Tables 11 and 12 as well as Figures 12 through 18 characterize locational TRI air emissions data for Region 6.

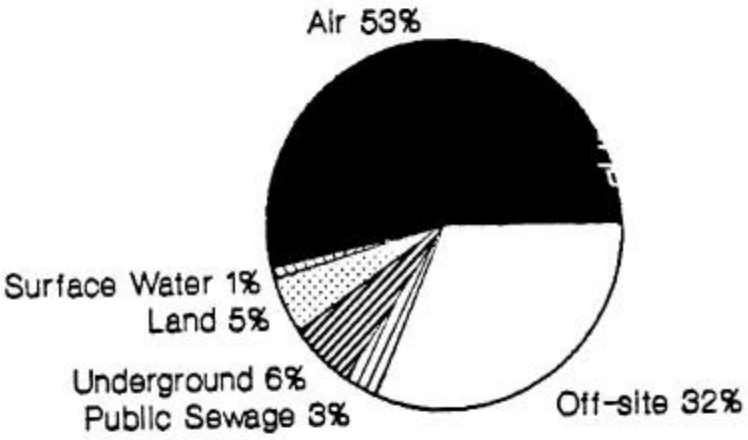
Table 8
Environmental Distribution or the 25 Carcinogens with the largest TRI Releases and Transfers, 1988.

Carcinogen Rank 1988	1987	Chemical	TRI Total (Lbs)	Air* %	Surface Water %	Land %	Under-Ground %	Public Sewage %	Off-Site%	Total %
1	1	DICHLOROMETHANE	134,212,442	85.54	0.20	0.11	0.23	1.90	12.01	100
2	2	STYRENE	42,760,770	78.61	0.14	0.57	0.00	0.69	19.99	100
3	4	TETRACHLOROETHYLENE	35,879,858	86.45	0.10	0.29	0.20	1.45	11.51	100
4	5	BENZENE	33,245,252	85.09	0.14	0.67	1.91	3.32	8.87	100
5	7	FORMALDEHYDE	30,766,305	40.08	0.00	2.49	31.23	14.53	8.74	100
6	6	CHLOROFORM	26,604,039	85.36	4.11	0.26	0.14	4.61	5.52	100
7	10	ACETONITRILE	23,585,619	8.67	0.18	0.01	70.92	1.86	18.36	100
8	9	ASBESTOS (FRIABLE)	22,607,674	0.19	0.05	4.49	0.42	0.09	94.76	100
9	3	LEAD	22,434,784	4.31	0.53	36.99	0.00	0.49	57.69	100
10	8	CHROMIUM	21,296,563	2.19	0.39	43.56	0.13	2.35	51.38	100
11	13	ACRYLONITRILE	10,841,495	38.95	0.05	0.02	42.09	8.82	10.08	100
12	19	POLYCHLORINATED BIPHENYLS	9,286,906	0.00	0.00	0.04	0.00	0.32	99.65	100
13	11	NICKEL	8,999,97	3.75	0.96	11.28	0.16	2.57	81.28	100
14	12	1,2-DICHLOROETHANE	7,567,049	53.03	0.52	0.03	6.16	2.34	27.93	100
15	14	1,3-BUTADIENE	7,212,227	88.72	5.72	0.11	0.00	0.62	4.32	100
16	16	CARBON TETRACHLORIDE	5,085,155	74.02	0.31	0.29	1.93	0.10	23.35	100
17	15	ETHYLENE OXIDE	5,053,707	90.86	0.88	1.08	0.22	6.52	0.43	100
18	17	PROPYLENE OXIDE	4,625,911	64.09	2.43	0.21	24.08	8.80	0.38	100
19	18	DI-(2-ETHYLHEXYL)PHTHALATE	3,506,080	31.07	0.09	0.58	0.09	5.57	62.43	100
20	21	VINYL CHLORIDE	2,072,382	66.97	0.10	0.11	0.00	0.83	32.00	100
21	26	1,4-DICHLOROBENZENE	2,007,383	90.08	0.31	0.05	0.75	1.89	6.92	100
22	20	ISOPROPYL ALCOHOL	1,672,949	68.29	0.00	0.00	0.00	4.24	27.47	100
23	27	1,4-DIOXANE	1,092,862	48.84	17.48	0.05	0.00	14.37	19.26	100
24	28	ACRYLAMIDE	1,032,887	2.52	0.30	0.07	85.10	1.31	10.70	100
25	33	HEXACHLOROBENZENE	970,287	0.51	0.00	0.00	0.04	0.02	99.43	100
SUBTOTAL OF 25 CARCINOGENS			464,420,557	59.98	0.77	4.58	7.63	3.00	24.04	100
TOTAL FOR OTHER CARCINOGENS			7,216,203	35.53	0.85	4.73	11.34	9.60	37.96	100
		CARCINOGEN TOTAL	471,636,760	59.61	0.77	4.59	7.69	3.10	24.25	100

Nineteen of the top twenty-five carcinogens have the majority of their releases to air.
Source: TRI National Report, 1990.

Figure 9

Environmental Distribution of TRI Carcinogenic Releases and Transfers



Total: 574.6 Million Pounds

Source: TRI National Report, 1990.

Table 9

REGION 6 AIR RELEASES BY STATE
(1988 TRI DATA, APRIL 1990)

State	Air Emissions Pounds	Percent[a]	Ranking Air[b]	Total[c]
Arkansas	46,801,874	1.93	21	25
Louisiana	131,070,512	5.48	4	1
New Mexico	1,883,293	0.08	47	39
Oklahoma	31,100,849	1.28	27	31
Texas	169,936,759	7.00	1	2
Totals				
Region 6[d]	382,793,287	15.77	1	1
National	2,427,570,103	100.00	-	-

[a]Percent of national air releases.

[b]National ranking for each state for air releases. Texas released more chemicals to the air than any other state. Louisiana was fourth.

[c]National ranking for each state for total chemical emissions.

[d]Region 6 released 15.77 percent of the reported air releases in the nation. Air releases accounted for 23.72% of the Region's total releases to all media. Texas and Louisiana combined to release 79.16% of the total air emissions for Region 6.

Source: TRI National Report, 1990.

Table 10

REGION 6 EMISSIONS AND POPULATION DENSITY
(1988 TRI DATA, APRIL 1990)

State	Total Land Area[a] (Sq. mi.)	Total Population (1000x)	TRI Emissions (pounds)	Population Density (pop./sq.mi)	Emission Density[b] (lbs/sq.mi.)
Arkansas	53,187	2,388	72,272,458	45	1,359
Louisiana[c]	47,751	4,461	741,206,814	93	15,522
New Mexico	121,593	1,500	24,398,821	12	201
Oklahoma	69,956	3,272	51,720,309	47	739
Texas	266,807	16,789	724,477,706	63	2,715
Region 6	559,294	28,410	1,614,076,108	51	2,886
National	3,622,425	246,051	6,241,030,746	68	1,723

[a] Land area and population statistics are from the Statistical Abstract of the United Stat@s, 1989 (Washington D.C., U.S. Dept. of Commerce, Bureau of the Census, 1989).

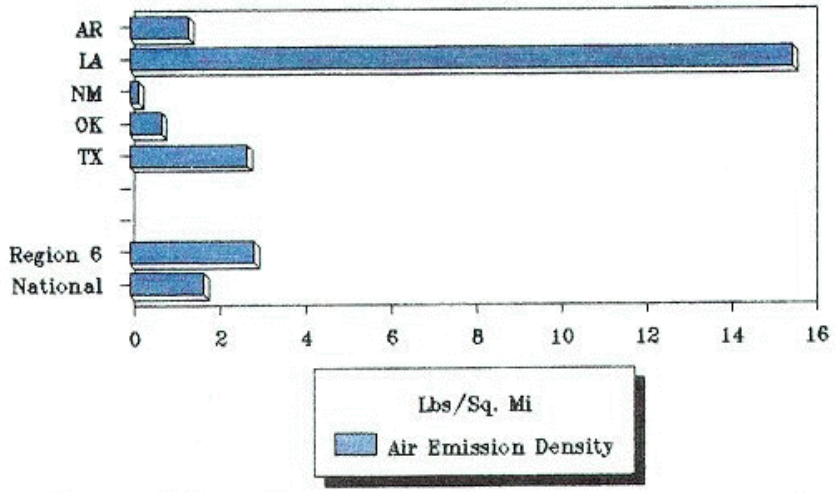
[b] Pounds of release or transfer reported per square mile.

[c] Nationally, Louisiana had the largest total releases (excluding off-site transfers) per square mile (14,989). This was 10 times the National average.

Source: TRI National Report, 1990.

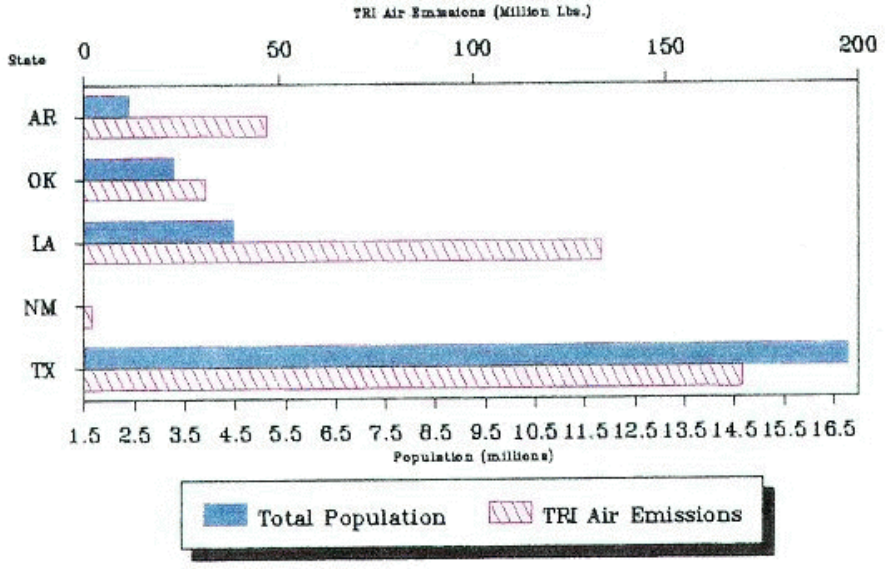
Figures 10 and 11

Region 6 Emission Density
Total Releases/Transfers
(1988 TRI Data, August 1990)



Source: TRI National Report, 1990.

Air Emissions & Total Population
(1988 TRI Data, August 1990)



Source: TRI National Report, 1990

TABLE 11
1987 ADJUSTED TRI DATA
(APRIL 1990)

REGION 6 COUNTIES AMONG THE 25 COUNTIES
WITH THE LARGEST RELEASES AND TRANSFERS OF CARCINOGENS

RANK	COUNTY	STATE	CARCINOGEN RELEASES (lbs)	PERCENT OF STATE RELEASE
1	Harris	TX	30,472,867	42.90
2	Jefferson	LA	14,272,800	39.37
6	Brazoria	TX	9,101,704	12.81
8	Jefferson	TX	7,753,964	10.92
17	Calcasien	LA	5,190,727	14.32
20	Ascension	LA	4,599,175	12.69

TOTALS (pounds)	
Region 6 (6/25 counties)[a]	71,393,237
National (25 counties)	193,668,859
National Grand (all counties)	574,553,378

[a] Region 6 released or transferred 37% of the total releases for the top 25 counties in the nation. These six counties account for 12% of the total releases of carcinogens in the U.S.

Table 12

Populations of Selected Region 6 Counties

Dallas County	1,641,400
Harris County	2,684,100
Galveston County	207,600
Jefferson County	257,400
Nueces County	283,100
Orange County	88,200
El Paso County	513,400
Tarrant County	929,000
East Baton Rouge Parish	366,191
West Baton Rouge Parish	19,086
Iberville Parish	32,159
Calcasieu Parish	167,223
Orleans Parish	557,515
Tulsa County	517,000

Figure 12

1988 COUNTY POPULATION & TRI DATA – AIR RELEASES IN REGION 6

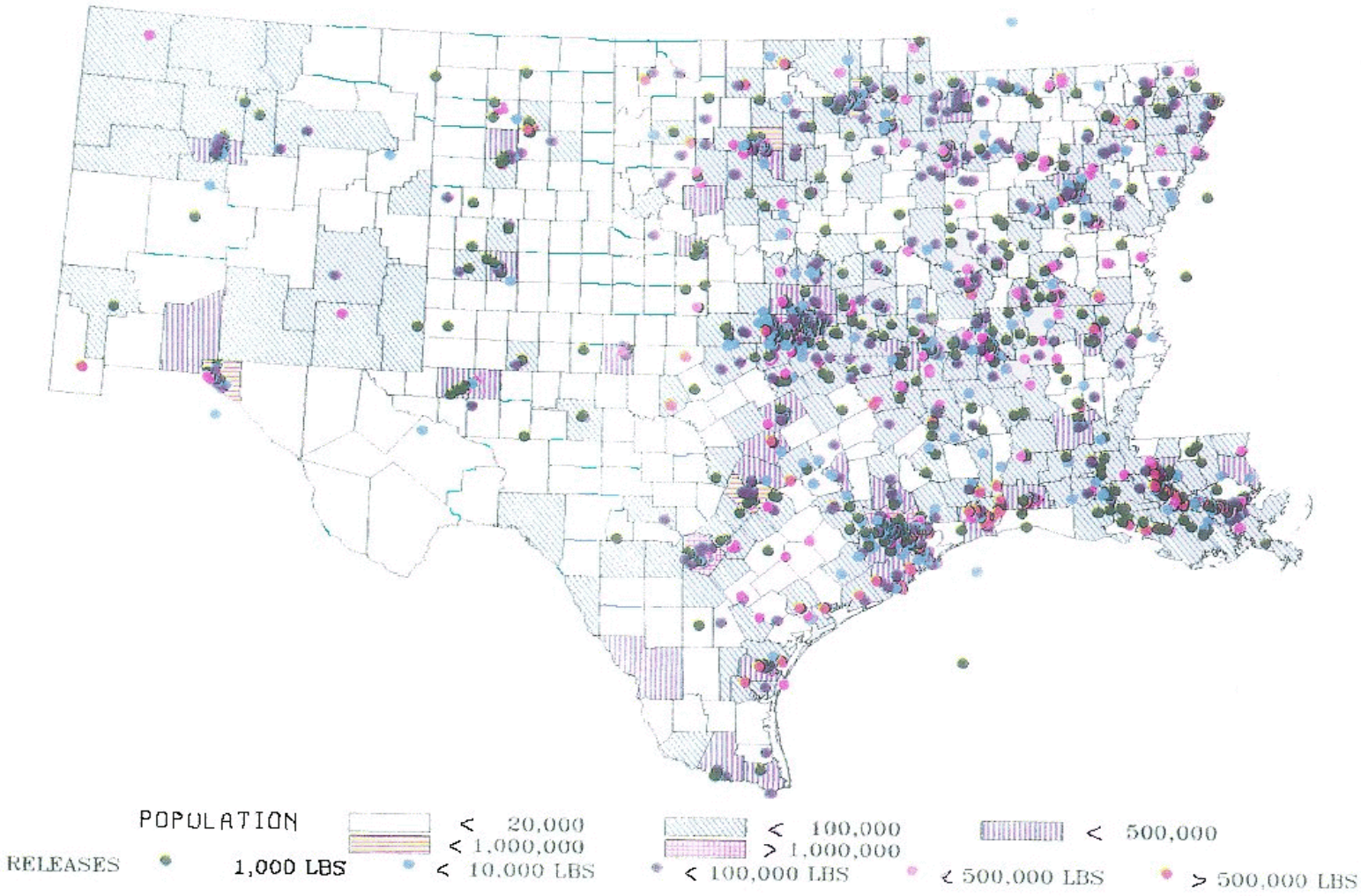


Figure 13

1988 COUNTY POPULATION DATA – TEXAS

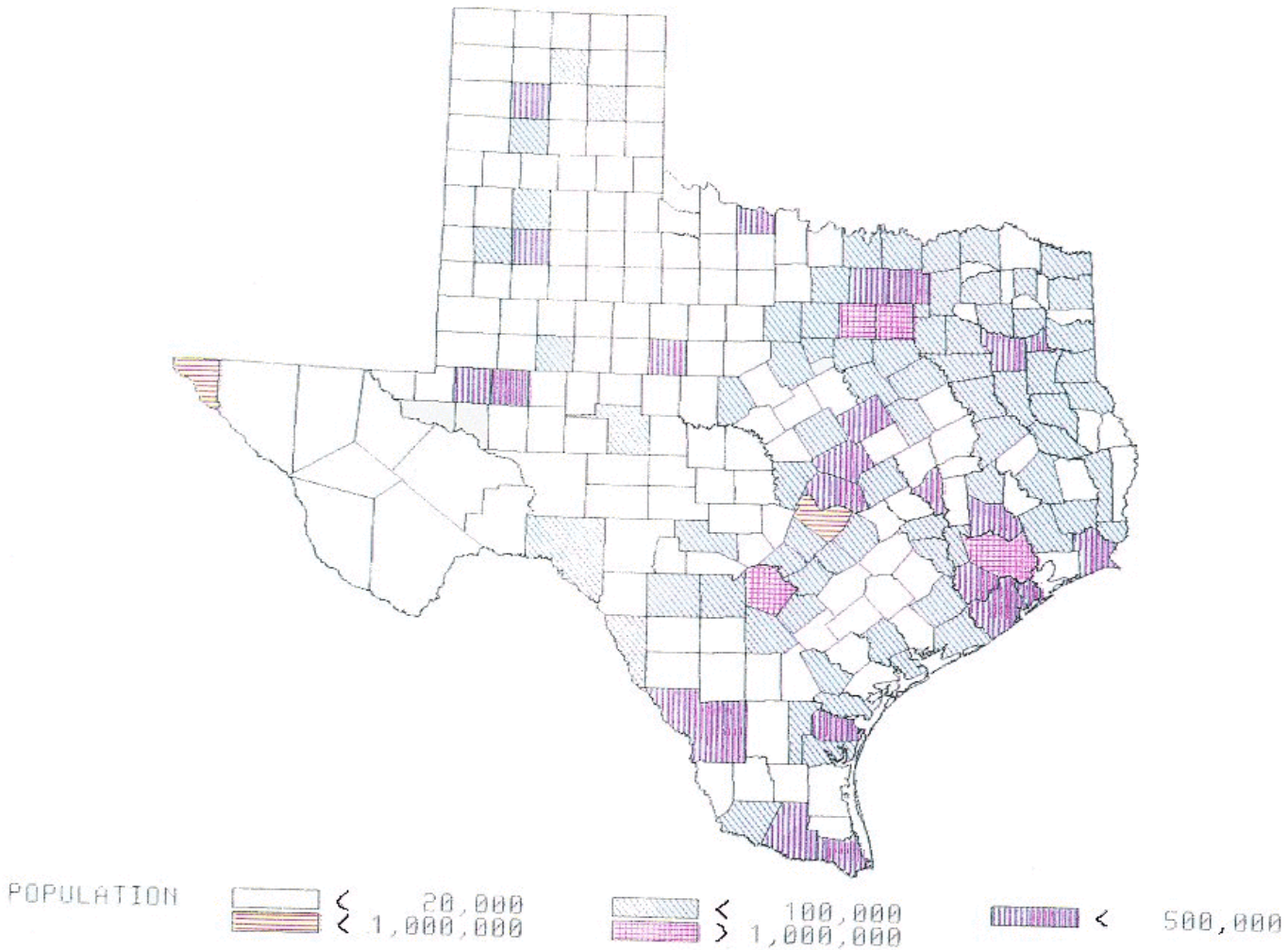


Figure 14

1988 COUNTY POPULATION & TRI DATA – AIR RELEASES IN LOUISIANA

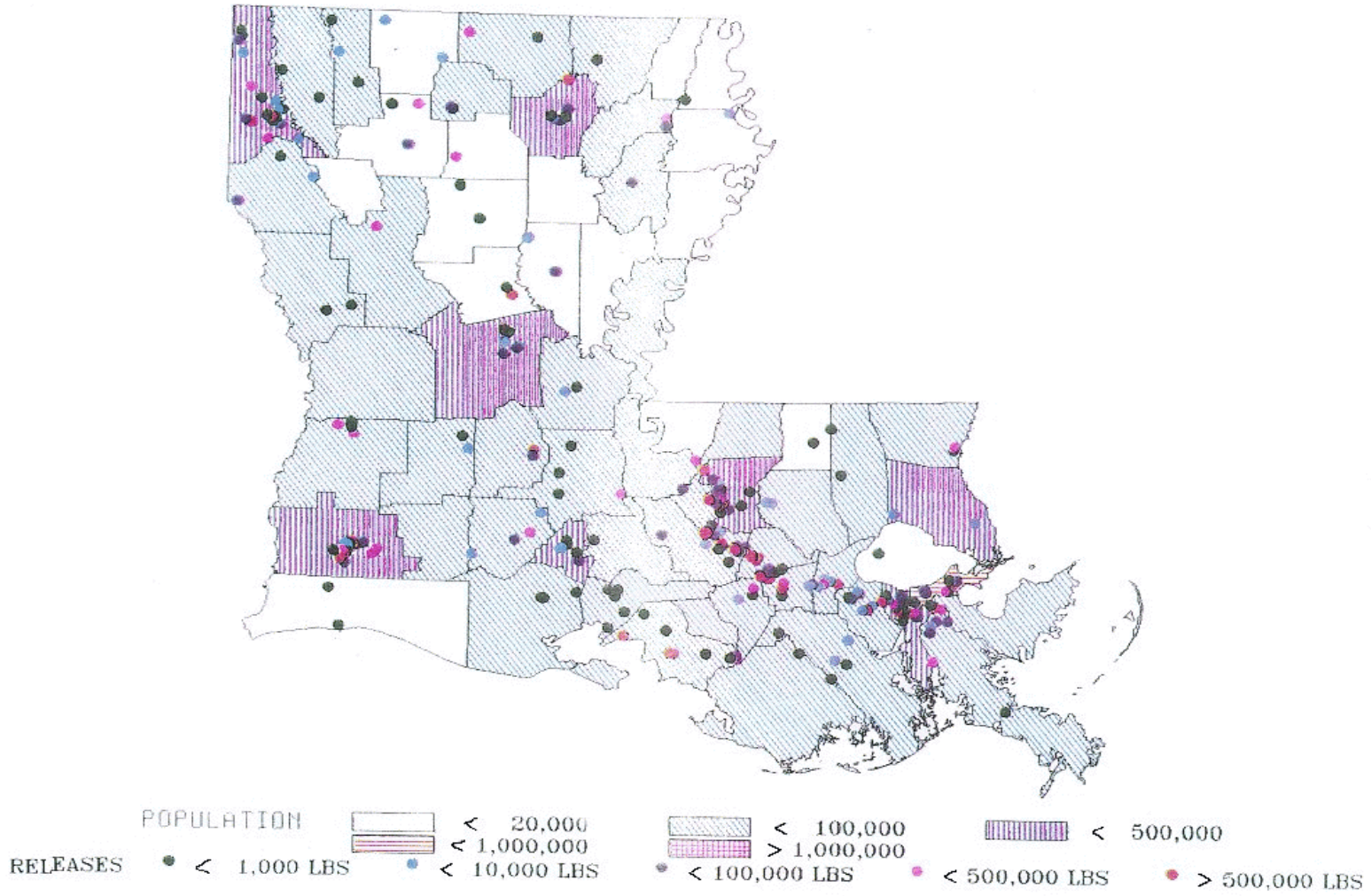


Figure 15

1988 COUNTY POPULATION & TRI DATA – AIR RELEASES IN TEXAS

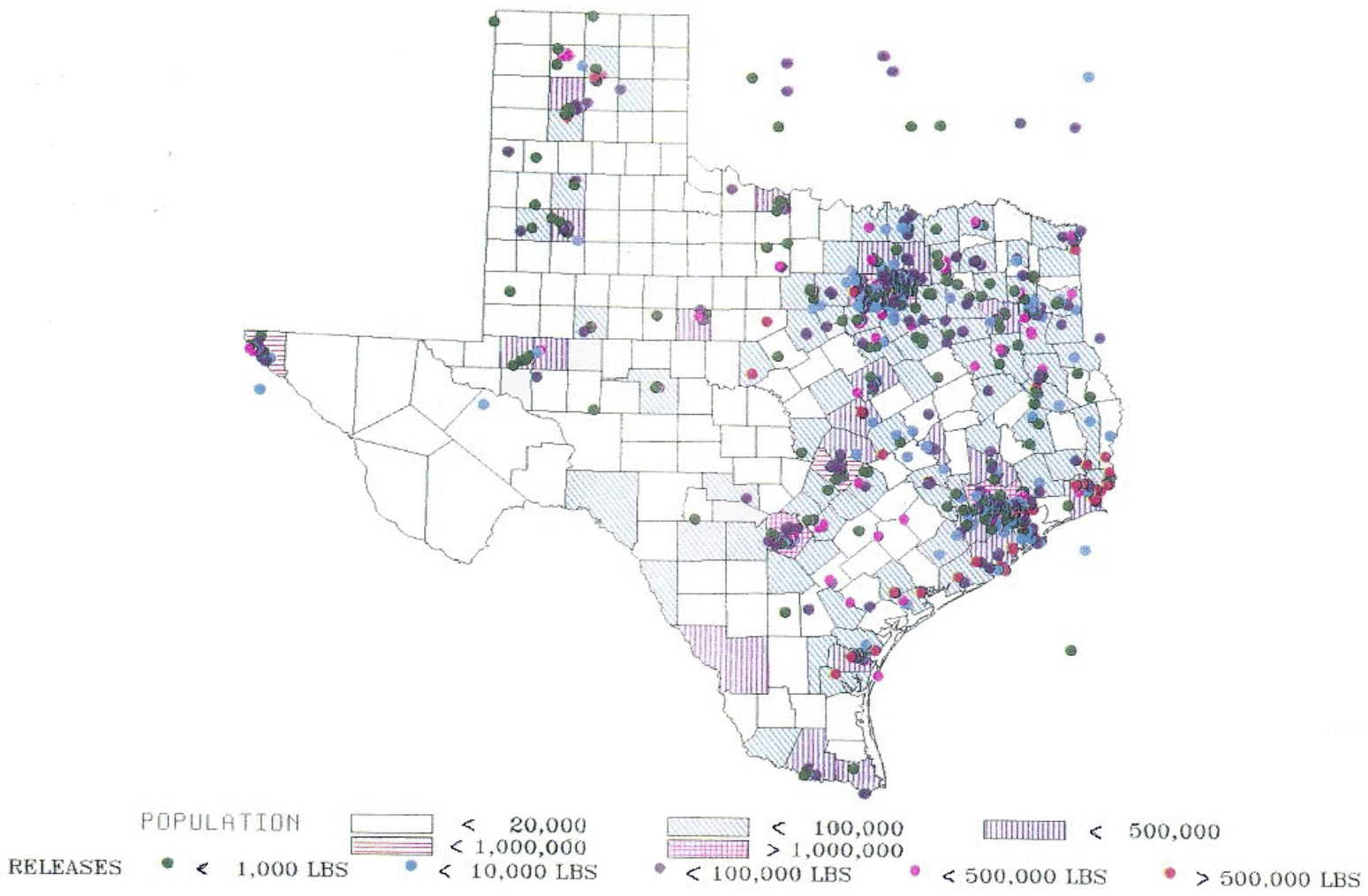
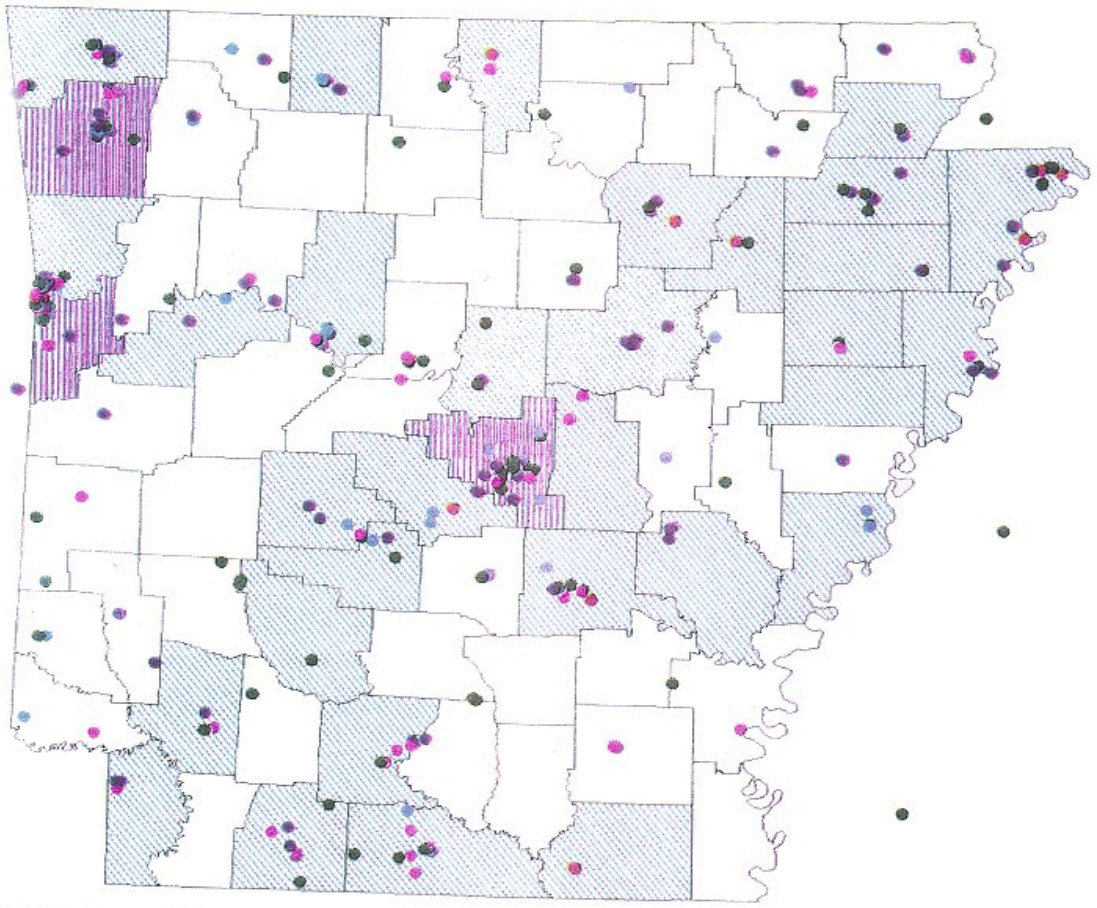


Figure 16

1988 COUNTY POPULATION & TRI DATA – AIR RELEASES IN ARKANSAS



POPULATION
< 20,000
< 100,000
< 500,000
< 1,000,000
> 1,000,000

RELEASES
< 1,000 LBS
< 10,000 LBS
< 100,000 LBS
< 500,000 LBS
> 500,000 LBS

Figure 17

1988 COUNTY POPULATION & TRI DATA – AIR RELEASES IN OKLAHOMA

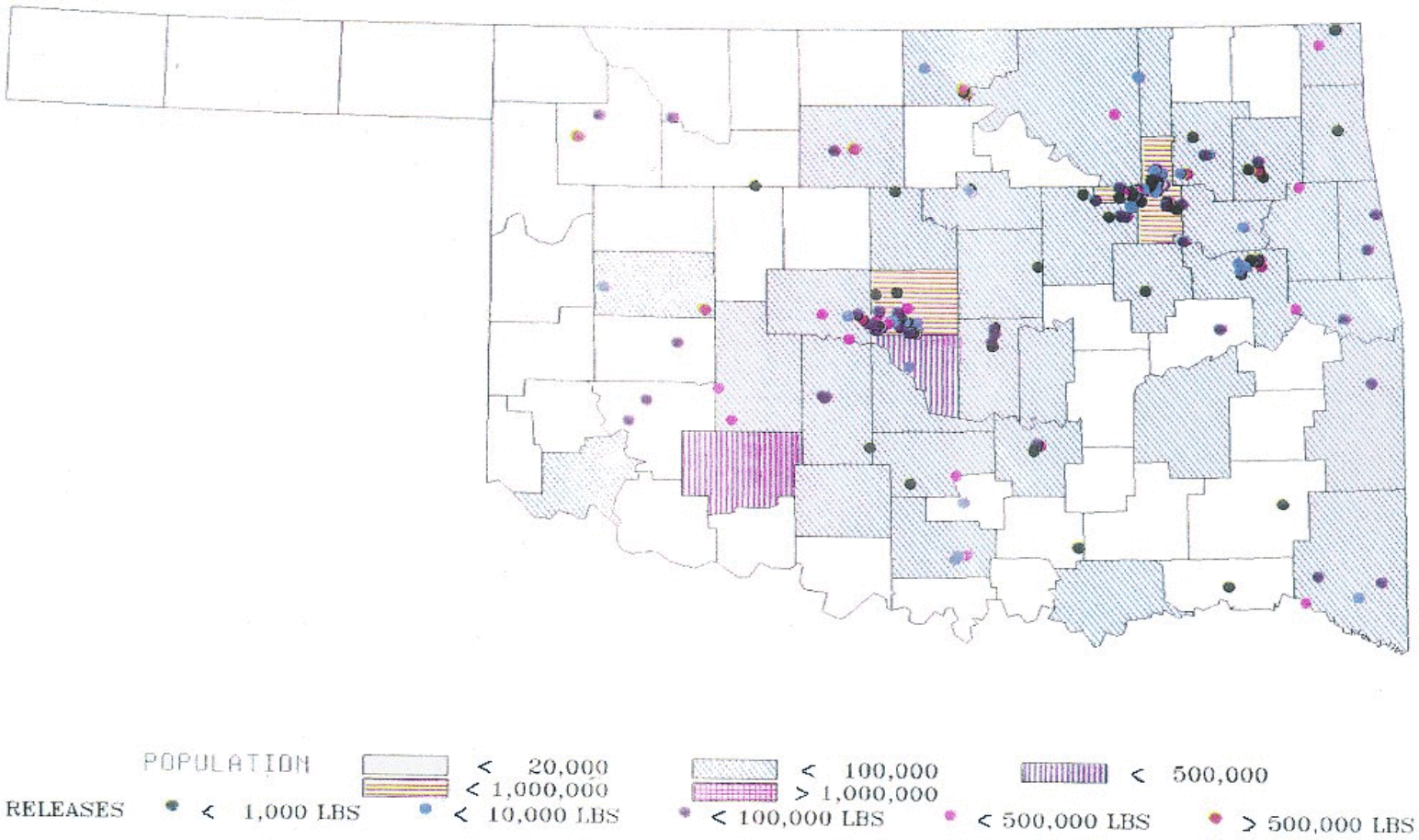
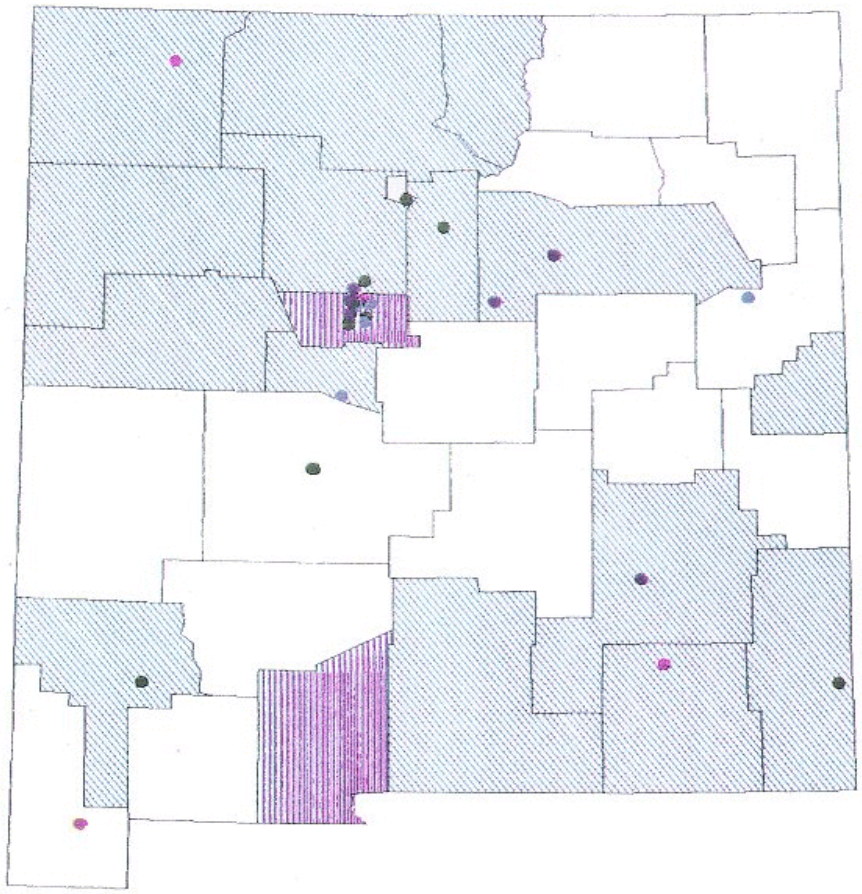


Figure 18

1988 COUNTY POPULATION & TRI DATA – AIR RELEASES IN NEW MEXICO



POPULATION < 20,000 < 100,000 < 500,000 < 1,000,000 > 1,000,000

RELEASES < 1,000 LBS < 10,000 LBS < 100,000 LBS < 500,000 LBS > 500,000 LBS

Discussion of Global Warming and Stratospheric Ozone Depletion

The global warming problem area was not ranked by the Human Health workgroup because the members did not feel confident projecting the results of this environmental problem, however, the Ecological and Economic workgroups ranked this problem in the highest category. Because the environmental causes of this problem (chemical emissions to air from mobile and nonmobile sources) is very much a part of many of the problem areas that were ranked (i.e., all discharges to water, land, pesticides, ozone/carbon monoxide, $S0_2$-NO_x, hazardous air toxics, and others); it is appropriate to discuss the problem. Global warming was ranked in the highest risk categories by both the Ecological and Economic workgroups.

Global Warming

The sun is the source of all energy on earth. It is also the controller of our climate. The problems concerning amounts and different wavelengths of sunlight predict not only energy usage (biomass production) but also the global temperature (climate). The physical-chemical make-up of our atmosphere serves to convert sunlight to infrared radiation (heat) and trap this radiant energy. Without the earth's atmosphere the planet would be frozen. Water vapor and atmospheric gases (greenhouse gases) are responsible for the trapping of the sun's heat. Through time, a delicate balance has been established between energy being received from the sun and the amount that the earth holds as heat. Because the sun is an extremely stable energy source, changes in our earth's temperature and climate ultimately reside with the greenhouse gases. Earth's atmosphere is ninety-nine percent oxygen and nitrogen. These gases are <u>not</u> efficient absorbers of radiant energy. The presence of greenhouse gases, although often only present in trace amounts, are powerful heat absorbers. Water vapor, carbon dioxide (CO_2), methane (CH_4), and nitrogen dioxide (NO_2) are the primary greenhouse gases.

The earth has balanced its atmospheric concentrations of water vapor, CO_2, methane, nitrogen oxides and other greenhouse gases through various chemical-biological cycles. Water vapor is a product of evaporation and returned to the earth's surface as rain or snow, CO_2, cycles involve the use Of $C0_2$ by plant photosynthesis (sunlight is the energy source) to produce energy-laden carbohydrates (complex sugars, starches, cellulose). These carbohydrates comprise three-quarters of the dry weight of all vegetation. Carbon dioxide is also removed from the atmosphere through photosynthetic activities of plankton (microscopic life forms) in the earth's oceans. An equivalent amount of $C0_2$ is released back to the atmosphere by chemical respiration, diffusion, and the decay of animal and plant matter.

Fossil fuels such as coal, oil, and natural gas are carbon sources that were deposited in the earth millions of years ago as dead plant and marine animals. The burning of fossil fuels in the past decades is now believed to be altering the natural balance of atmospheric greenhouse gases.

Nitrogen dioxide (NO_2) is a very efficient greenhouse gas. This gas can absorb 100 times as much heat as $C0_2$. Nitrogen can cycle through the biosphere as plant microorganisms fix atmospheric nitrogen, the plant decays, and nitrogen is eventually released back to the atmosphere.

Methane is generated by bacteria catabolizing (biochemically breaking down) organic matter in the absence of oxygen (anaerobically). This occurs in marshes, rice fields, guts of cattle, and landfills. Methane absorbs 20 to 30 times more heat than $C0_2$.

The above greenhouse gases are major players in global warming. Warming of the planet is occurring because of increases of $C0_2$, methane, nitrogen oxides and other heat absorbing gases. These increases are being caused by man's activities. Clearly the greatest contributing gas is CO_2. And the primary source of the additional $C0_2$ is the burning of petroleum and other fossil fuels.

Methane, nitrogen oxides, and other heat absorbing gases are being released into our atmosphere at alarming rates. We may bum petroleum carbon resources in as little as 200 years. It required millions of years for nature to deposit these resources.

Figure 19, 20, 21, and 22 show environmental trends over the past decades. Carbon dioxide emissions have resulted in the measurable increase of annual $C0_2$ concentrations from approximately 315 parts per million (ppm) to 345 ppm. Carbon dioxide has increased by 25% since the industrial era began. Ibis trend has been accelerating over the past three decades. Methane is produced naturally as mentioned above, but is also emitted to the atmosphere through anthropogenic sources such as the increase in the total numbers of ruminants (cattle, sheep, goats), burning of biomass (trees, trash), and through the production of coal and natural gas. These sources contribute about 15 to 20 percent of the man-made sources of methane.

Nitrogen dioxides are produced by combustion or when nitric oxide combines with oxygen in the atmosphere. The later process proceeds rapidly in the presence of sunlight and hydrocarbons. The yellow-brown cast seen in urban air is primarily due to NO_2. Nitrogen dioxide concentrations greater than 1 ppm can affect human health and some sensitive plants (Environmental Trends, 1989). Nitrogen oxide emissions result almost entirely from motor vehicle, industry, and electrical energy producers. Global atmospheric concentrations of NO_2 have increased recently as Figure 22 illustrates.

The mean surface temperature of the earth has been increasing over the last 100 years. Although, some scientists believe that this maybe normal fluctuation in climate. The present warming trend is consistent with the above mentioned increases in greenhouse gases. This is sufficient to be defined as a first order variation, or changes that can be documented within a 10 year period and can be seen over a lifetime (Figure 23).

Ozone formation in the lower atmosphere will also absorb heat. Ozone is considered to be a greenhouse gas. Ozone is formed in part by greenhouse gases and ozone is a hazardous air pollutant contributing annually to both respiratory and cardiovascular disease in the U. S. Chlorofluorocarbons (CFCs) are also greenhouse gases. These chemicals contribute to ozone formation in the troposphere (lower atmosphere). Emissions of CFCs have also increased over the past few decades (Figure 24).

If global warming occurs, and many scientists believe it has begun and is inevitable, it could change the earth's surface temperature by two to five degrees Celsius (3º - 9º Fahrenheit) by year 2050. Discussion of the impacts of this climatic change are filled with uncertainty. Projecting one-hundred years into the future is extremely difficult, but everyone agrees that the possible impacts are so great that the world can not wait for conclusive proof before we take preventive actions. Global warming would make droughts and violent storms more frequent, cause a rise in sea level, and cause fauna and wildlife to migrate With the changing habitat or perish. Sea level rise would have a great effect on the Gulf Coast and the wetlands of Louisiana in particular. A sea-level rise of one foot would cause costal water-lines to move inland 100 to 200 feet in Maryland, 200 to 1,000 feet in Florida but, several miles in Louisiana.

At the heart of the global warming issue are air emissions of organic compounds. Toxic Release Inventory information can become a measure of success or failure in attempts to decrease these emissions. TRI can also facilitate the identification of industry released chemicals contributing to the formation of greenhouse gases. Previous tables and figures have illustrated the contributions that Region 6 is making to the air toxics problem. Regional toxic air releases may in fact be much more of a ecological concern than an immediate threat to human health. Everyone's health and welfare will be affected if increased atmospheric concentrations of hazardous air toxics continue. Figure 5 clearly shows that organic, non-metals, and halogenated organics are primarily released to air. Figure 25 compares Region 6 air emissions with those of other regions. Also recall that Texas and Louisiana have extensive petroleum and chemical industries which would release a variety of greenhouse gases.

The outlook is uncertain for reductions in toxic air pollution in the near future. Our region should continue to increase in population (Figure 26). This is a problem because automobile emissions are a significant source of air pollutants. There does not seem to be a significant effort by the public to reduce their use of personal vehicles (Figure 27). Region 6 ranks 4th among EPA regions in vehicle miles driven (Program Report No. 18A, Appendix D). Region 6 motorist drive about 13 percent of the nations total miles.

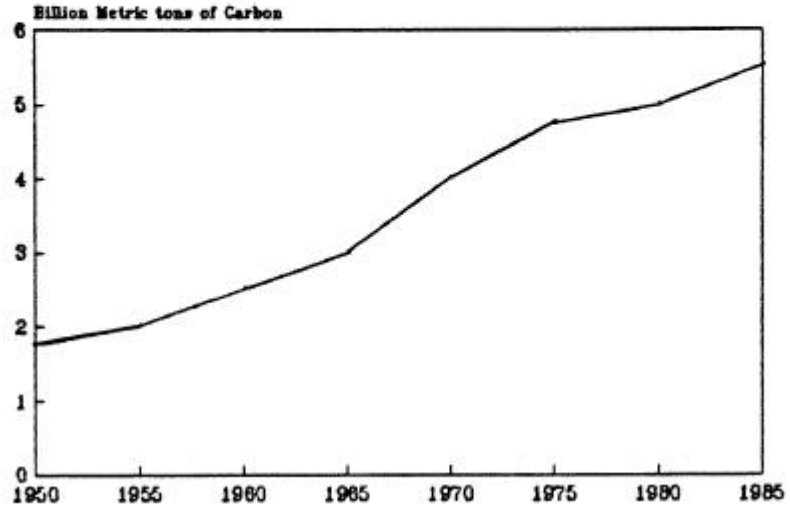
Stratospheric Ozone Depletion

Another global problem area which is primarily caused by air toxics is stratospheric ozone (0_3) depletion. Upper atmosphere ozone absorbs the sun's harmful UV-B radiation. This radiation has been shown to cause skin cancers, cataracts, and immune system depression. Halogenated hydrocarbons (organics containing chlorine, fluorine, iodine, or bromine atoms) are believed to be direct causes of the chemical destruction of this protective ozone layer.

These chemicals, also called CFCs chlorofluorocarbons are used as refrigerates in automobiles and home appliances, by industry as cleaning fluids (de-greasers), as blowing agents for foam material and as fire retardants (halons). The destruction of ozone by chlorine is illustrated in Figure 28. Nitrogen oxides are also implicated in the chemical reactions which release free halogen atoms to attack ozone (O_3).

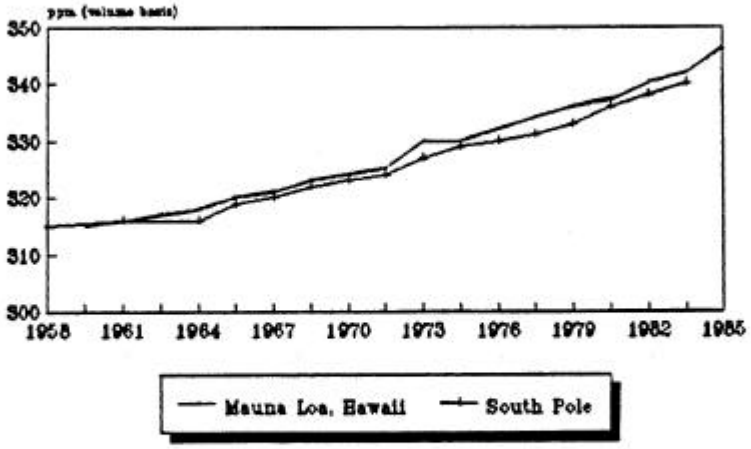
Figures 19 and 20

Global Carbon Dioxide Emissions from Anthropogenic Sources, 1950 – 1985



Source: Environmental Trends; 1989

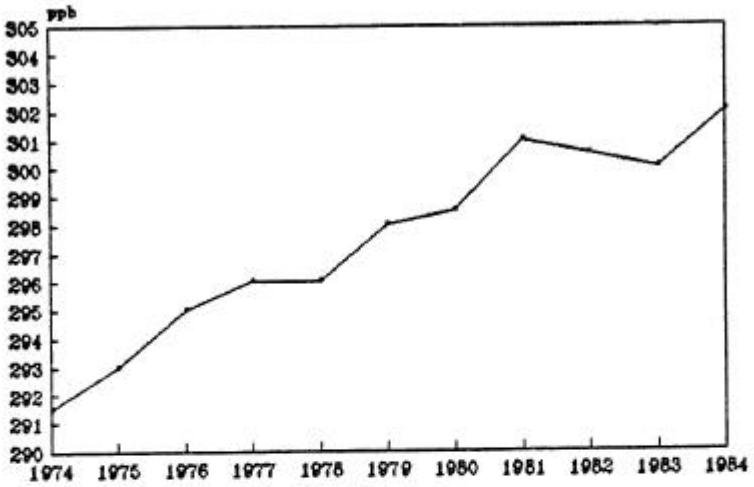
Average Annual Concentrations of Carbon Dioxide in the Atmosphere 1958 – 1985



Source: Environmental Trends; 1989

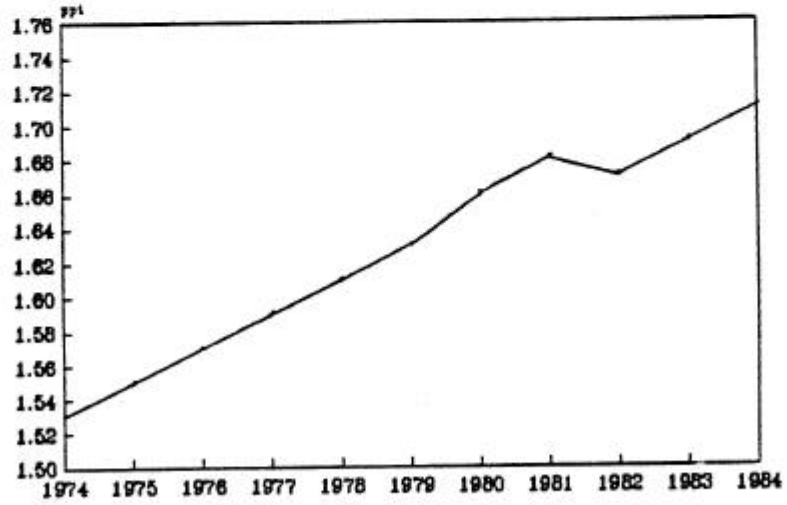
Figures 21 and 22

Global Atmospheric Concentrations of Nitrogen Dioxide, 1974 - 1984



Source: Environmental Trends: 1989

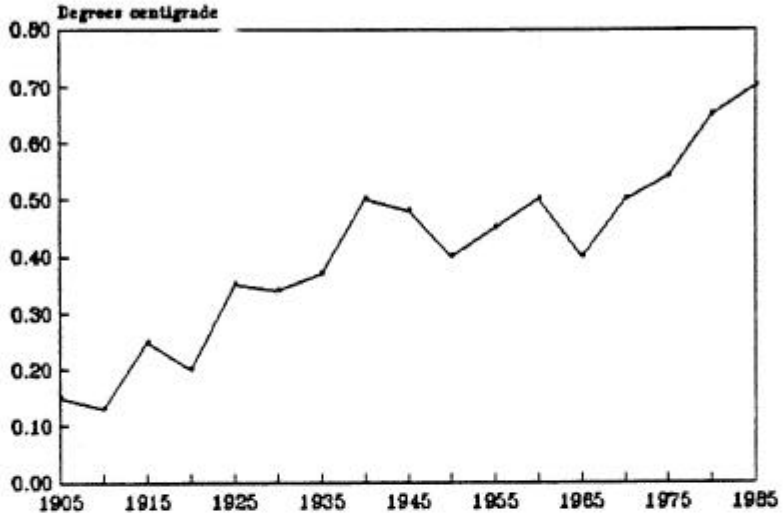
Global Atmospheric Concentrations of Methane, 1974 - 1984



Source: Environmental Trends: 1989

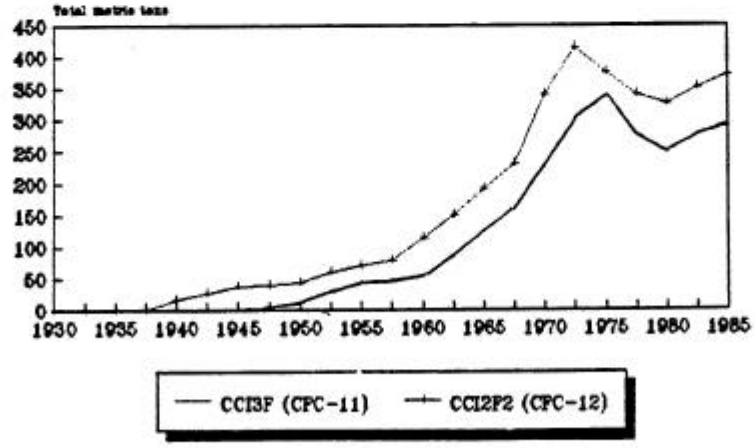
Figures 23 and 24

Variations in Global Mean Annual Surface Temperature, 1905 – 1985



Source: Environmental Trends; 1989

Annual Emissions of Chlorofluorocarbons 1930 – 1985



Source: Environmental Trends; 1989

A CFC atom when struck by UV-B light energy causes a free chlorine atom to be released (CI^-) which chemically attacks an ozone molecule. The chlorine atom - ozone reaction yields oxygen (0_2) and a free oxygen atom (-O-) which combines with a chlorine atom to form chlorine monoxide (ClO). This compound then can react with another oxygen atom (-O-). Oxygen (0_2) is again formed and the now free chlorine (Cl^-) attacks another ozone (0_3) molecule. This destruction may occur as often as 1,000 times for a single chlorine atom. CFCs can take years to reach the stratosphere and the compounds can exists for decades.

Region 4's comparative risk report, Assessing the Comparative Risk of Global Climate Change and Stratospheric Ozone Depletion (August 1990), was used to estimate the future health impacts of depletion of stratospheric ozone. Because ozone depleting chemicals released today will exist in the atmosphere for decades to over one-hundred years, the health risks were projected to the year 2075. The annual estimates of cancer cases and associated mortalities for Region 6 were: 1,167 melanoma skin cancer cases, 232,772 non-melanoma cases if no CFC controls are implemented (276 and 4,069 mortalities per year respectively). With Montreal Protocol controls strictly observed the estimates are 105 melanoma and 12,506 non-melanoma skin cancer cases (25 and 201 deaths per year respectively).

All residents of Region 6 are “at risk”. Fair skinned people are most susceptible but, any resident can suffer immune system depression. Such disorders can cause anyone to be more susceptible to disease. Non-cancer risks include cataracts and diseases facilitated by immune system depression. Region 6 estimates of UV induced cataracts are 28,625 if no CFC controls are implemented and 2,544 if controls are observed. The environmental trend for global CFC concentration change shows a steady increase from 1974 to 1994 (Figure 29).

In 1987 EPA predicted that for every one percent drop in global ozone, there would be a one to three percent increase in skin cancers. From extensive studies by NASA and NOAA scientists (March 1990), it is believed that global ozone has decreased by at least two percent in the past ten years. Because cancers have a long latency period, these incidence numbers may continue to rise for many more years.

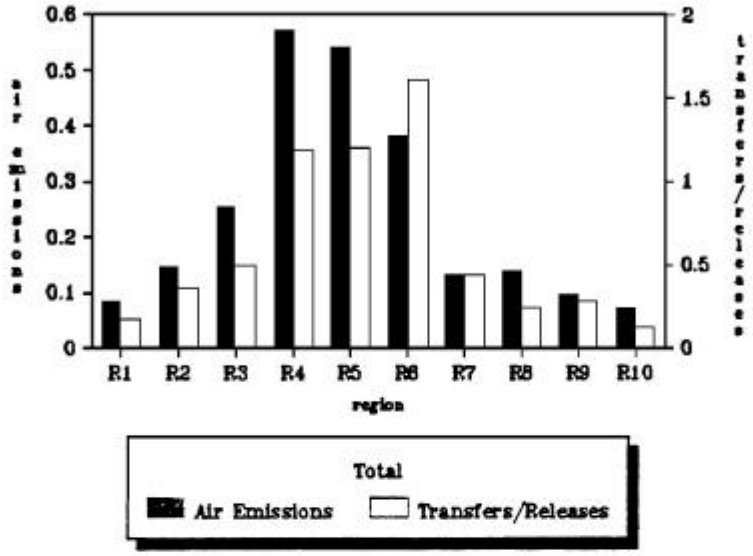
There are many ecological and welfare-economic risks associated with increased UV-B exposure. UV radiation is routinely used in sterilization processes both in medicine and the consumer products industry. It is not surprising that it is damaging to many forms of life.

Increased UV-B radiation has been shown to adversely affect agricultural crop yields and crop quality. Region 4's report predicted effects based on a 25 percent reduction in stratospheric ozone by the year 2075. Soybean crop sensitivity studies suggest that decreases in crop yields at 20 to 25 percent would be expected. Increased UV-B radiation may have devastating affects on many plant species possibly rendering them more susceptible to damage from pests or disease.

Fish and shrimp larvae have been shown to be particularly sensitive to UV-B irradiation. Many larva stages of aquatic organisms may be affected. Our Gulf Coast fishing industry would be impacted significantly because over 90% of the Gulf's commercial fishing species have a life cycle stage in near coastal waters.

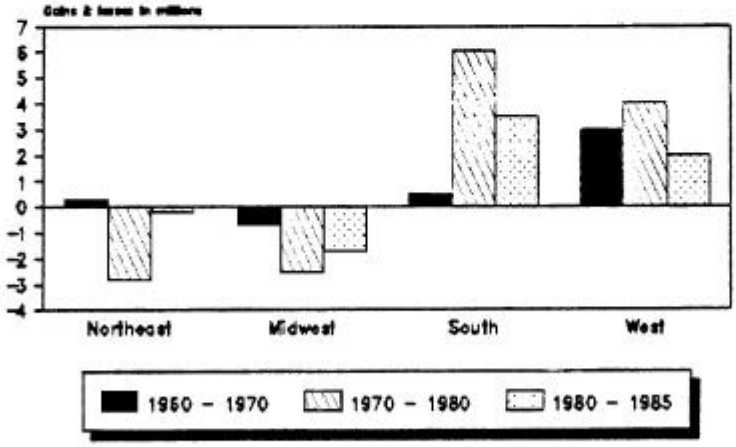
Figures 25 and 26

Air Emissions & Total Transfers/Releases



Source: TRI National Report, 1990

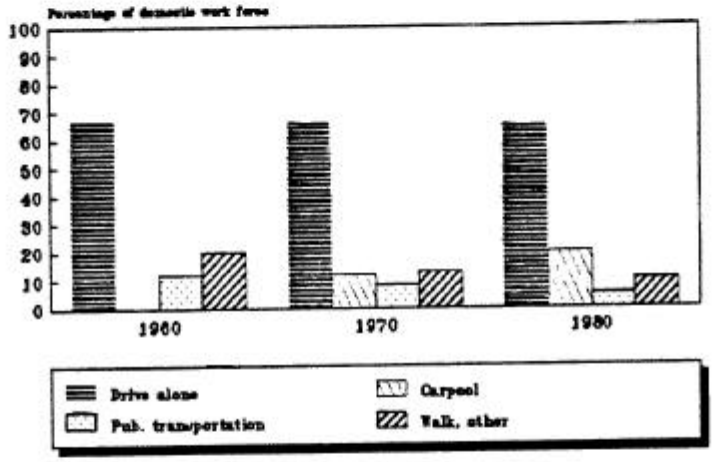
Net Population Migration by Region 1960 – 1985



Source: Environmental Trends, 1989

Figure 27

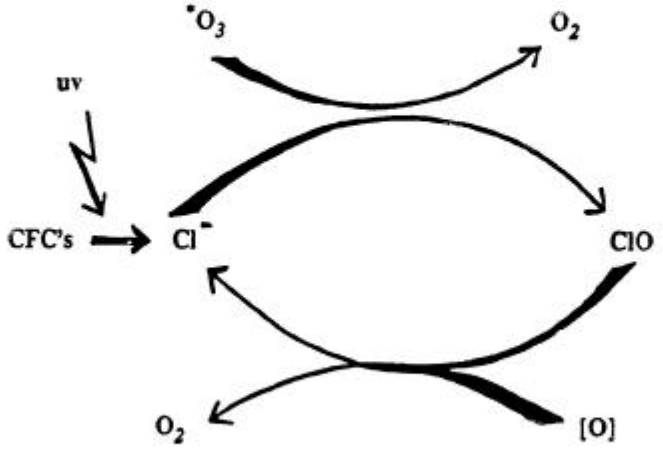
Means of Transportation to Work
1960 – 1980



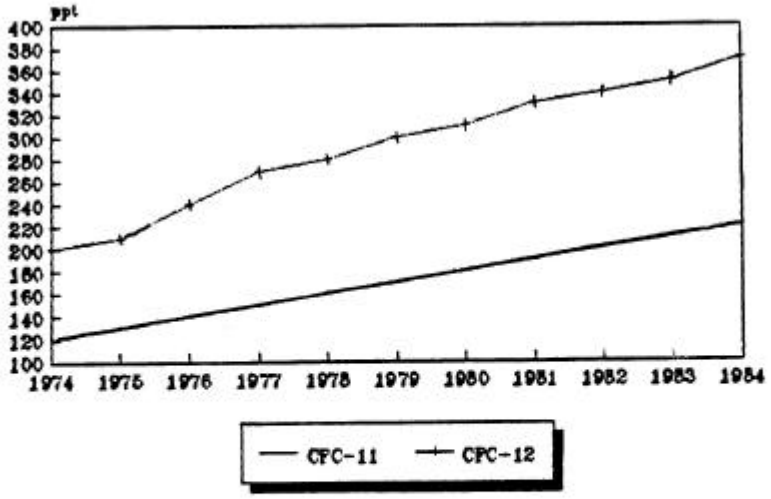
Source: Environmental Trends, 1989

Figures 28 and 29

Chlorofluorocarbons and Ozone Depletion



Global Atmospheric Concentrations of Chlorofluorocarbons, 1974 – 1984



Source: Environmental Trends 1989

UV-B radiation is capable of penetrating many feet into the water. This would be especially harmful to aquatic and terrestrial species in the Texas and Louisiana wetlands. Of enormous concern is the possible decrease in phytoplankton in the oceans. A 25 percent decrease in the ozone layer is estimated to decrease phytoplankton productivity by 35 percent. This would have a global impact on the basic aquatic food chain as well as the $C0_2$ cycle. (Recall that phytoplankton and oceans are important in global warming as a major $C0_2$ sink)

An analysis of TRI data shows ethyl chloroform, CFC-113, and carbon tetrachloride are major ozone depleting chemicals emitted by industries. According to the 1988 Toxic Release Inventory data, 254,048,768 pounds of these emissions were released nationwide. Region 6 has the following amount of these emissions per state.

STATE	POUNDS/YEAR	PERCENT OF NATIONAL TOTAL
Arkansas	3,876,606	1.53
Louisiana	1,937,137	0.76
New Mexico	727,521	0.29
Oklahoma	2,346,370	0.92
Texas	10,602,428	4.17
TOTAL	19,490,062	7.67

Therefore, TRI industries in Region 6 emit 7.67 percent of the total releases of these three ozone depleters. In addition, Texas is ranked eighth in the nation for CFC releases. Figures 30 and 31 show the regional and state CFC emission comparisons. Figures 32 through 35 display the location and amount of emissions for Region 6 and selected Region 6 states.

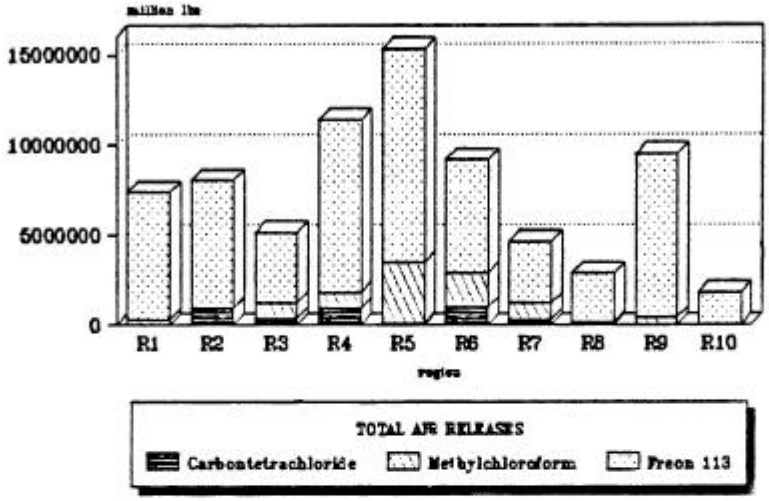
The Montreal Protocol, signed in 1987, limits the production and consumption of ozone-depleting chemicals. The treaty has been ratified by the United States and 51 other countries. The goal of the Protocol is to reduce the production and consumption of CFCs by 50 percent of 1986 levels.

The Protocol also freezes the production and consumption of halons at 1986 levels beginning in 1992. EPA issued a final rule on August 12, 1988 which regulates producers and importers of CFCs through a system of allowances. The rule does not regulate the actual users of CFCs. There are three companies in Region 6 that are affected by the Montreal Protocol. They are:

Facility	Location
DuPont	Ingleside, TX
Allied-Signal	Baton Rouge, LA
Kaiser	Gramercy, LA

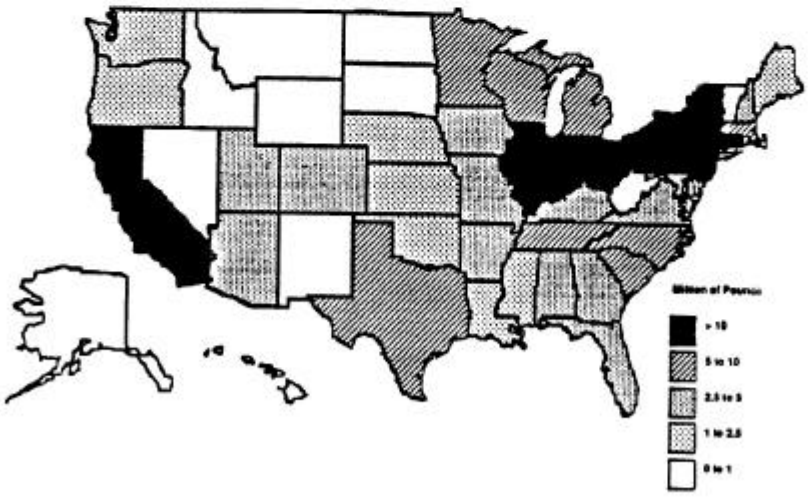
Figures 30 and 31

Ozone – Depleting Emissions
1988 TRI Data (August 1990)



Source: TRI Database, August 1990

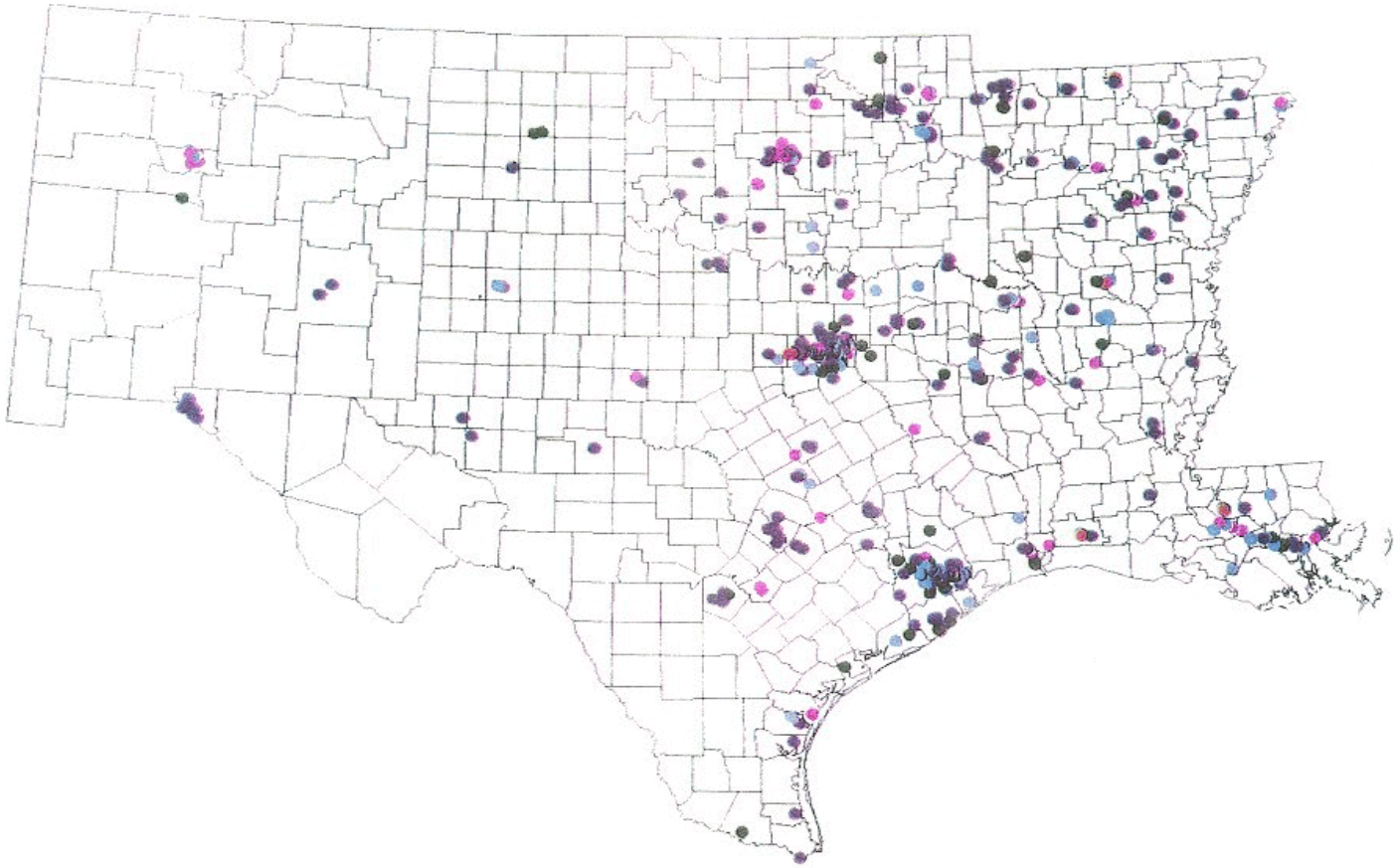
AIR EMISSIONS OF OZONE DEPLETING CHEMICALS



Source: TRI NATIONAL REPORT; 1990

Figure 32

TRI DATA – CHLOROFLUOROCARBON (CFC) EMISSIONS IN REGION 6



LEGEND: < 1,000 LBS < 10,000 LBS < 100,000 LBS < 500,000 LBS > 500,000 LBS

Figure 33

TRI DATA – CHLOROFLUOROCARBON (CFC) EMISSIONS IN TX

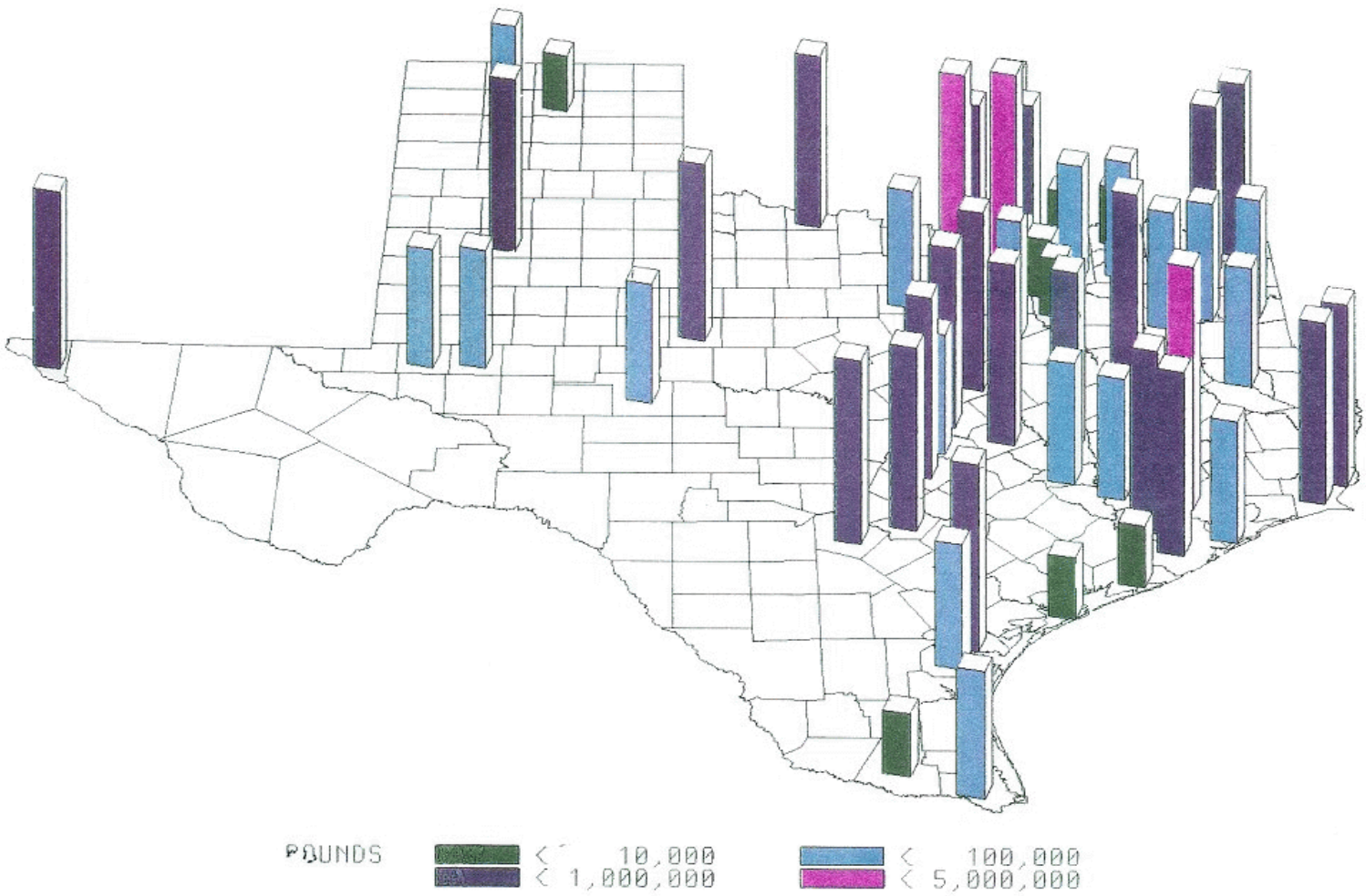


Figure 34

TRI DATA – CHLOROFLUOROCARBON (CFC) EMISSIONS IN AR

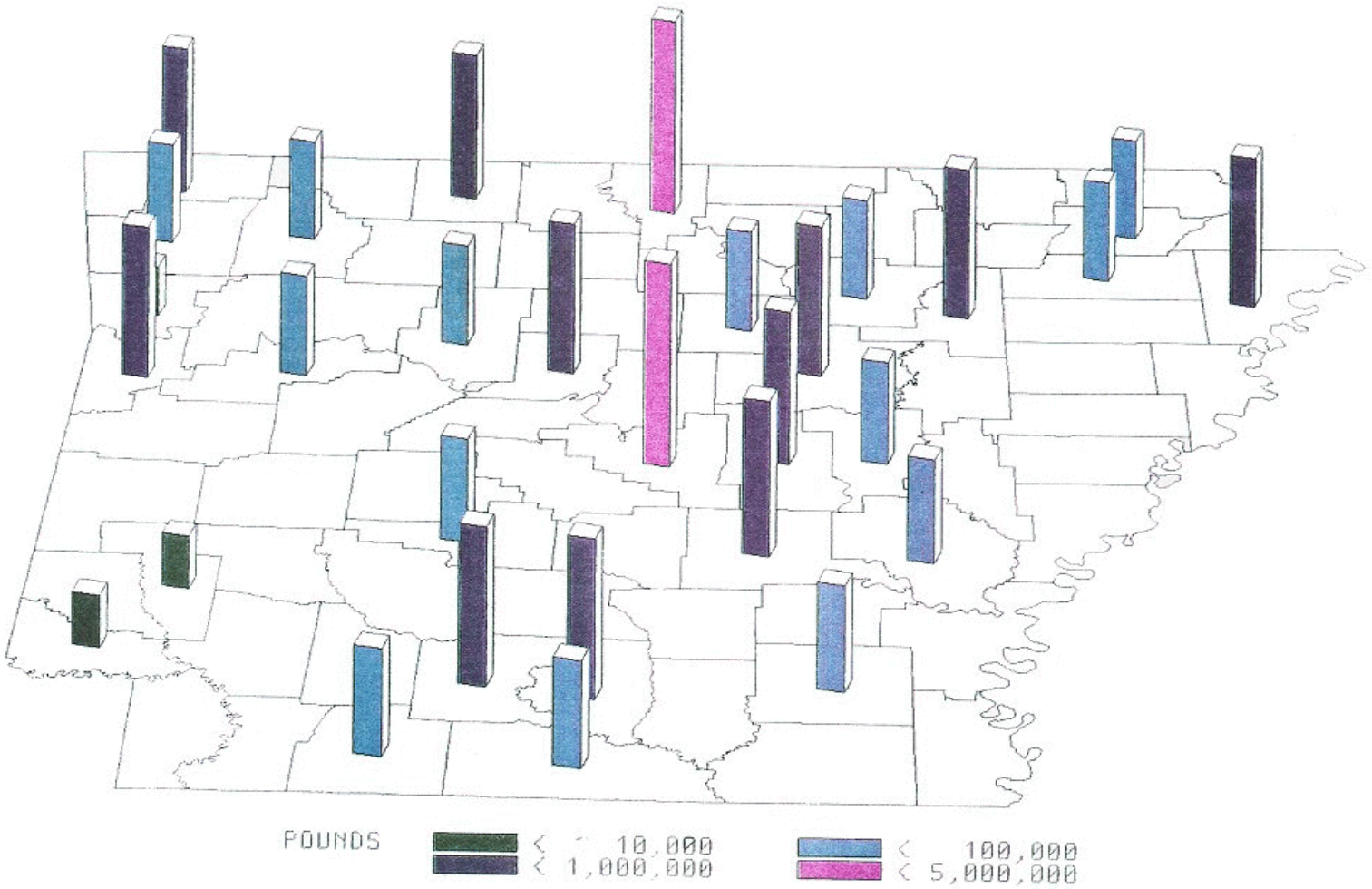
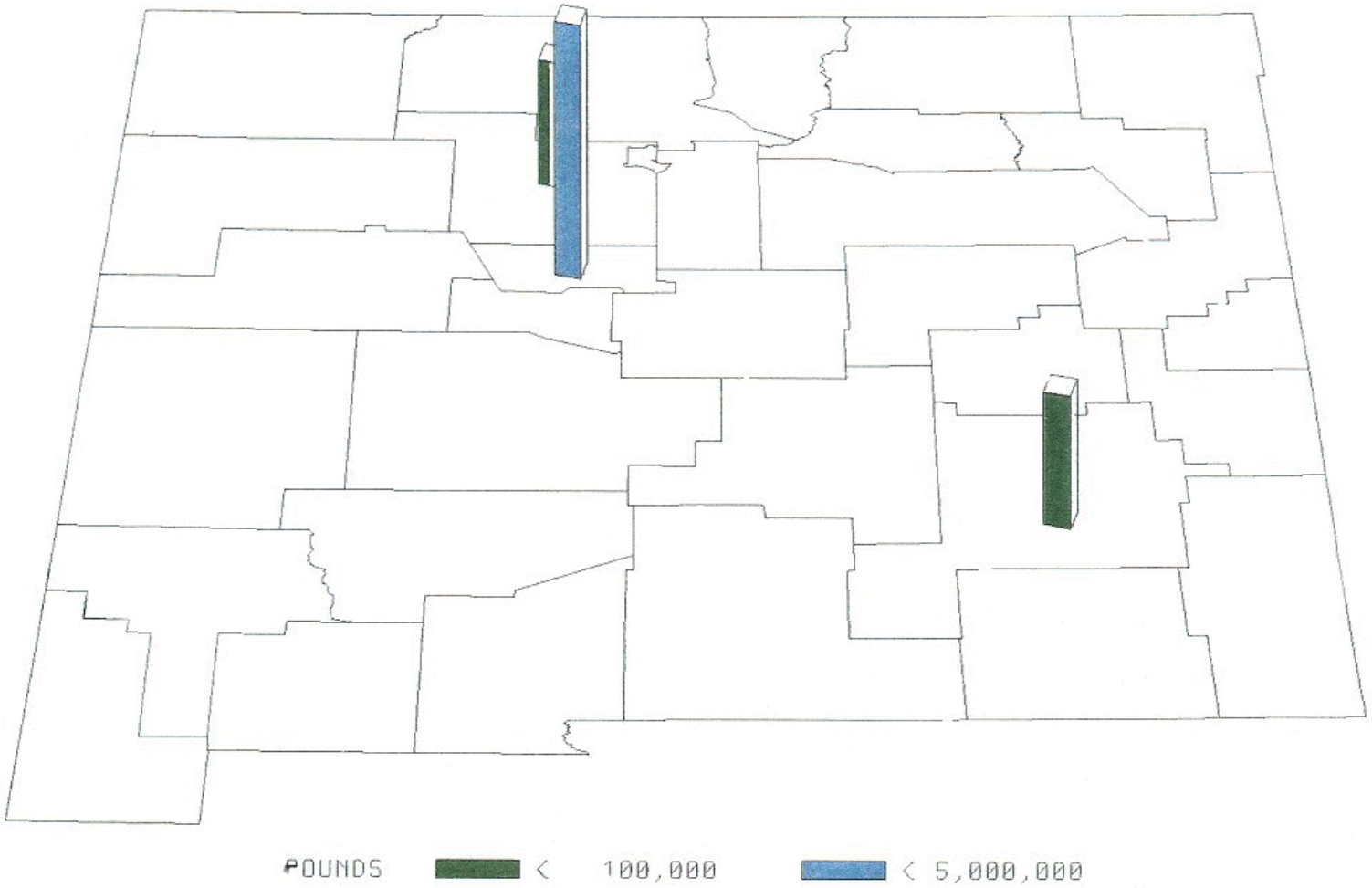


Figure 35

TRI DATA – CHLOROFLUOROCARBON (CFC) EMISSIONS IN NM



On May 1, 1990, EPA published an advance notice of proposed rule making for controlling and recycling air conditioning coolants and other chemicals that deplete the stratospheric ozone layer. In addition, the Clean Air Act Amendments being deliberated in Congress call for recycling and phase out programs for CFCs (Program Report No. 23A, Appendix D).

Summary

The release of hazardous/toxic air pollutants as defined in problem area number 18 (Attachment A) is not only a major cause of air pollution effecting the health of Region 6 residents, but is also the primary source of greenhouse gases and stratospheric ozone depleting chemicals.

Toxic release inventory data analysis and basic knowledge of environmental toxicology and chemistry supports this conclusion.

Discussion of Pesticides, Radon, Indoor Air Pollution, ans Ozone/Carbon Monoxide

Pesticides

The term selective toxicity refers to compounds which cause harm to a very limited number of species or one type of living matter. This would certainly be the goal of insecticides and herbicides, but in truth few if any such compounds are truly selective. Pesticides are applied to crop land, transportation thoroughfares, in and around our homes and businesses. Humans often co-inhabit areas with plant and animal pests. Therefore, we often encounter pesticides in our dwellings and foods.

Pesticides are unique of all the chemicals produced and used by man. They are formulated for the purpose of chemically causing injury to living organisms. Given the general lack of specificity, care must be taken to avoid direct contact with pesticides. Toxicologists must also be aware of non-target species such as wild and domestic animals, and humans. The target organisms usually have some disadvantage making them more susceptible. An insect's smaller size, but larger body area per weight, means that a small amount of poison will be injurious relative to larger animals. Their chitin exoskeleton can be more susceptible to absorption of a pesticide formulation. Plants also offer differences which make them vulnerable for selective attack. For example plants have cell walls (animals have lipid-protein cell membranes), photosynthetic biochemistry, and the absence of nervous systems and an elaborate circulatory system. These are just a few of the variables that are exploited to develop selective poisons to control non-economic species. Region 6 has a large agriculture industry which applies a substantial amount of insecticides and herbicides annually. The Ecological comparative risk workgroup estimated that pesticides are applied to approximately 41,552,000 acres for specific crops in our five states.

The Pesticides program staff estimates the Region has 1,154,393 farm workers, 29,915 commercial applicators, and 232,341 private applicators. Potential routes of exposure to these workers include dermal, oral, and inhalation. Residential exposures to the Region 6 population

was estimated by assuming 7.1 million households and 3 people per household. The additive estimated annual incidence of cancer from a specific group of pesticides used in Region 6 was over 2,000 cases. The workgroup stated that the Region has a large farm labor force with many crops requiring hand labor practices. They also stated that most pesticides in general use have not been adequately characterized as to their toxicological potential (Program Report No. 13A, Appendix D).

The workgroup identified fourteen pesticides for non-dietary risk analysis. Several of the compounds were organophosphate insecticides. Organophosphates such as Diazinon, Malathion, and Methyl Parathion are commonly used both commercially and by home owners. Organophosphates owe their toxicity to the inhibition of the enzyme acetylcholinesterase (AChE). Inhibition of ACHE causes the accumulation of acetylcholine (ACh) which is a neurotransmitter in man and insects. The resulting paralysis of ACh sensitive tissues (muscles) causes death in the insects and can cause a variety of symptoms in man to include death due to asphyxiation from respiratory failure. Many other pesticides are neurotoxins. Carbaryl and Propoxur are carbamate ACHE inhibitors. Dieldrin and DDT also have neurotoxicity activity.

The persistence of pesticides in the environment and ultimately in the tissues of man, animals, and plants is of particular interest to toxicologists. For the same reasons discussed earlier, halogenated organic chemicals tend to persist for long periods in the environment. Dieldrin, DDT, Aldrin, Heptachlor, Mirex, Chlordane, and Lindane are such pesticides.

The same pharmacokinetic principles apply to pesticides as for air toxics. Compounds which are soluble in fat tissues tend to translocate through animal cell membranes and eventually bioaccumulate in adipose (fatty) tissues of the body. Figures 36 and 37 illustrate the detection of chlorinated organics in human adipose tissue (Environmental Trends, 1989). This source states that organochlorine pesticides can be detected in adipose tissue of virtually everyone in the United States. In many cases the concentrations are decreasing in humans (DDT, Dieldrin, some chlorobenzene compounds).

Halogenated pesticides can enter the environment's food chain through urban and rural runoff into lakes and streams and bioaccumulate in predators (fish, mammals, and birds). This can become a threat both ecologically and to human health. Also realize that greater than one-half of the nation's river drainage occurs through Region 6 to the Gulf of Mexico. Over one-half of all shellfish catches are off the shores of Texas and Louisiana, and two of the four major waterfowl flyways originate in the Texas and Louisiana coastal wetlands. There may be significant pesticide runoff to the coast. The potential for bioaccumulation of these lipophilic compounds in species of commercial fish and migratory birds is a Regional concern.

Summary

Pesticide application in Region 6 is extensive. The potential exists for farm labor and commercial applicator direct exposure. A large number of these 'at risk" populations are in the five states. The pharmacokinetics of the organochlorinated compounds, the well known neurotoxic effects of organophosphates, the obvious potential for wide-spread bioaccumulation

of chemicals in water, land, and wildlife, and the known carcinogenicity of many of the compounds, have allowed this problem area to be ranked in the highest risk category by the Human Health workgroup.

It should be mentioned that this is the only problem area where conditions of occupational exposures were considered for risk assessment data. The pesticides problem area was defined to include worker populations. EPA has regulatory authority which addresses labeling, application, and worker exposure.

Radon

EPA's cancer assessment methodology requires the review of animal and human epidemiology data, the monitoring of environments of concern, and the statement of assumptions and uncertainty factors. When these procedures are followed, exposures to radon produce high lung cancer incidence numbers. A national estimate of over 20,000 lung cancer cases per year is a estimate derived from good human epidemiology and animal data. Everyone **is** exposed to some concentration of indoor radon. More monitoring data is needed to determine the possible locations of highest risk from radon exposure.

Program Report No. 20A (Appendix D) describes the Region's radon cancer risk analysis. The monitoring of radon in Region 6 homes is being performed at this writing through the Agency's EPA/State Radon Survey program. The comparative risk report estimates over 1,900 annual lung cancer deaths with Texas contributing 1,330, Oklahoma 119, New Mexico 142, Louisiana 130, and Arkansas 216. The radon survey program is beginning to produce valuable home monitoring data that will continue to adjust the Regional cancer estimates and identify areas of greatest concern.

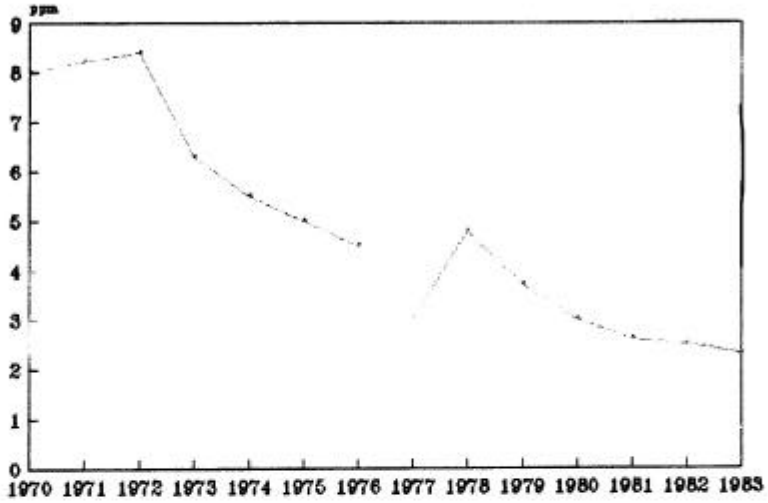
A problem within the Region, and nationally, is public apathy in testing their homes for high radon levels. The cost to test homes for radon is relatively small. The current action level for indoor radon is 4 pCi/L (picocurries/Liter). Regional data collected by EPA can serve to alert Region 6 residents of areas where homes have shown high readings.

Summary

Everyone in Region 6 is exposed to radon. Toxicological information from animal studies and human epidemiological research clearly indicates that radon gas causes lung cancer. EPA's cancer assessment methodology, the high number of residents exposed in the Region, and the solid animal and human toxicology data are the reasons that Indoor Radon is ranked in the highest Human Health risk category. This problem area has also been ranked high in all other EPA risk projects to date.

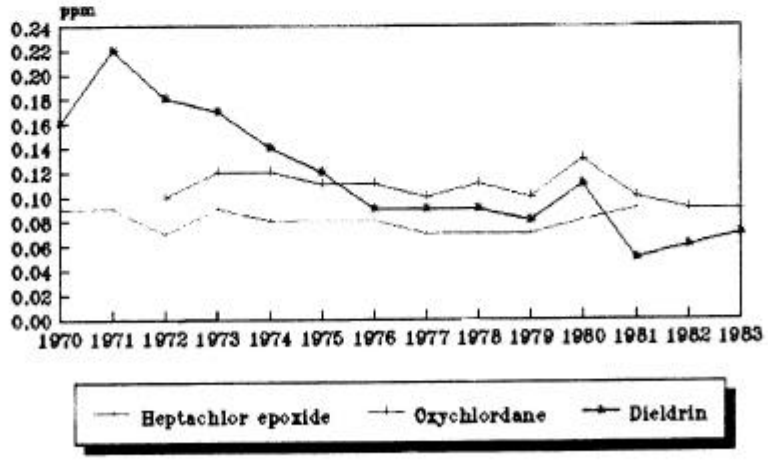
Figures 36 and 37

DDT Residues in Human Adipose Tissue (1970 – 1983)



Source: Environmental Trends; 1989

Pesticide Residues in Human Adipose Tissue (1970 – 1983)



Source: Environmental Trends; 1989

The one risk assessment area for radon where available data has not been strong is in the number and different locations of homes tested. As this data is gathered, a change in cancer incidence numbers may occur. Recent monitoring data of homes in Louisiana and Oklahoma has produced a downward adjustment of the cancer incidence numbers for Region 6. Texas and Arkansas monitoring programs are underway at this time.

Indoor Air Pollution

The Indoor Air Pollution problem area has an identified exposed population of all Region 6 residents, or approximately 28.5 million people. We spend 60 to 70 percent of our time in our homes and approximately 30 percent in places of business or school rooms. The population exposed includes many sensitive subpopulations such as newborns, children, the elderly, and heart , asthma, bronchitis, emphysema, and allergy patients. The possible contaminants can include virtually any chemical common to industry, medications, pesticides, bacteria, molds, fungi, asbestos, lead, carbon dioxide, and chemicals in tobacco smoke. Indoor concentrations of volatile organic compounds (VOCs) have been shown to be as much as 10 times outdoor concentrations U.S. EPA, TEAM study, EPA/600/6-87/002a). There is no reason to think that chemical carcinogens, corrosives, respiratory irritants, teratogens, mutagens, and even biological pathogens are any less toxic or infective because they reside within our homes.

A significant number of our Regional population is exposed to secondary cigarette smoke (second hand or side smoke). Exposure to the various compounds found in this pollutant can cause many adverse health effects including cancer, cardiovascular effects, respiratory effects, eye discomfort, headache, allergic reactions, fatigue, dizziness, sinus congestion, skin irritation, and nausea. Although these effects may appear common, they are serious and even life threatening to individuals whose health may already be compromised. Repace and Lowery (1985) have compared estimated risks from various hazardous air pollutants (Table 13). Estimated lung cancer deaths from passive smoking are approximately 200 times the estimates for other chemical pollutants. The authors point out that the chemicals assessed are all airborne carcinogens, and all are regulated by society except passive cigarette smoke. Although exposure to passive cigarette smoke has received State and Federal legislative attention recently, Table 13 still communicates a strong public health statement. It also demonstrates the high cancer incidence numbers that can be generated for indoor air exposures and why this problem area was ranked in the highest human health risk group in Region 6.

Pesticides are commonly detected in indoor air. Even pesticides that have been withdrawn from use (Chlordane, Aldrin, Dieldrin) are included in health evaluations because they are expected to remain in or around a residence for decades (Nonoccupational Pesticide Exposure Study, 1990). Therefore, there is potential exposure by inhalation, dermal contact, or oral ingestion by all members of a household.

Summary

Indoor air pollution contains many of the same chemicals found in the ambient outdoor environment. Often these chemicals are at higher concentrations indoors. The exposures are to

all Region 6 residents and to all sensitive subpopulations. This ubiquitous exposure includes volatile organics, gasoline, pesticides, biologicals, lead, asbestos, and many other potential toxicants. Many of the chemicals are carcinogens (i.e., formaldehyde, benzene, lead, asbestos). Title IV of the Superfund Amendments and Reauthorization Act of 1986 directs EPA to disseminate information on indoor air quality issues to the public, establish a research program, and submit indoor air quality reports to congress. Publications such as The Inside Story. A Guide to Indoor Air Quality (U.S. EPA/U.S. CPSC, 1988) will increase the public awareness of a substantial pollution problem effecting everyone's health.

Table 13
Risks From Hazardous Air Pollutants / Passive Smoking

Passive Smoking	5,000 LCD / yr	Repace, Lowery (1985)
Vinyl Chloride	< 27 LCD / yr	U.S. EPA (1975)
Radionucleotides	< 17 LCD / yr	U.S. EPA (1983)
Coke Oven Emissions	< 15 LCD / yr	U.S. EPA (1984)
Benzene	< 8 CD / yr	U.S. EPA (1979)
Arsenic	< 5 CD / yr	U.S. EPA (1980)

CD = cancer deaths
LCD = lung cancer deaths

Ozone/Carbon Monoxide

Ozone/Carbon Monoxide was the only problem area ranked in the highest human health risk group which did not have a significant cancer incidence component. The risk ranking was driven by the high number of exposed Region 6 residents estimated to be "at risk". Monitored concentrations of ozone in the Region were at levels documented to cause adverse health effects to sensitive human populations. The ranking also was a product of references to studies showing that ozone produced decreases in pulmonary function for active children at exposures below the regulatory ambient air standard of 0.12 ppm (Amdur, 1986).

Program Report No. 15A describes the areas in Region 6 which violate the National Ambient Air Quality Standards (NAAQS) for ozone and carbon monoxide (CO). The report estimates 11,126,499 people live in metropolitan areas which exceed ozone/CO NAAQS and that approximately 1,283,291 of these residents are either asthma, chronic bronchitis, emphysema, coronary heart patients, or pregnant women. These are “at risk” individuals who, unlike many at risk populations for other problem areas studied, are known to be affected by the monitored ambient concentration. For ozone and CO those concentrations were 0.12 ppm and 9 ppm respectively.

Questions regarding the exposure estimates for the Ozone/Carbon Monoxide ranking allowed a

detailed study of Regional monitoring data to be performed (Program Report No. 15D). Review of the monitoring methods for the NAAQS program revealed to the Human Health workgroup that the monitoring for these two pollutants appeared to be more extensive than for any other problem area studied. It was also realized that the Program Report used a higher ozone threshold value (0.12 ppm) as compared to other Regional risk projects (0.10 ppm). If Region 6 had used 0.10 ppm as the threshold value, a greater at risk population would have been identified.

Summary

It should be mentioned that problem areas, other than ozone/CO, could have also made the highest level of concern for non-cancer risks. Stratospheric Ozone Depletion, Indoor Air Pollution, and possibly Pesticides are such problem areas with substantial estimated or projected noncancer effects.

Ozone and carbon monoxide exposure in Region 6 appears to be well documented, adverse effect concentrations better defined, and Region "at risk" populations better identified than for many other problem areas studied. Therefore, the high risk ranking and high confidence in the data.

Ile Human Health workgroup encourages all reviewers to comment on the health risk rankings presented in Tables 3, 4, and 5. The workgroup also welcomes any additional data which may support a change in the group's evaluation of human health risk in Region 6.

RISK MANAGEMENT SUMMARY

The Region 6 Welfare Analysis and Risk Management workgroup was charged with identifying and evaluating the associated risk management factors for the 22 environmental problem areas listed in the "core list" which Regions 2, 4, 5, 7, 8, and 9 are also using. Risk management factors are concerns such as public perception, legal authority, or EPA resources which affect the ability of the Region to control environmental exposures and reduce risk. The management factors will serve as additional information to be used by Region 6 senior staff along with the welfare, health, and ecological impacts for developing and implementing strategies to control adverse environmental exposures.

The workgroup identified three risk management factors: public perception, legal authority, and effective technology. Each of the 22 environmental problem areas were evaluated on a scale of 1 to 5 for each management factor, with 5 indicating that the problem area was "difficult" to manage and 1 indicating that the problem was 'easy" to manage. Factors identified as being difficult to manage are of concern to the workgroup because if a problem area poses a high health or ecological risk, the difficulty in managing the risk hinders the region's ability to reduce the risk.

In assessing the factors, the workgroup focused on residual risk. Ibis is the risk associated with existing levels of regulatory control and compliance. In essence, it is a snapshot of the Region's environmental control in 1989. The summary evaluation for each factor is presented in Table 14.

In addition to the management factors, the workgroup identified which existing regional budget items are associated with each of the 22 problem areas. This information was compiled for use by regional senior managers in deciding the assignments of future resources towards reducing environmental risks.

Methodology

Because there is no one established methodology for addressing risk management factors, the Region 6 workgroup needed to develop a methodology which provides for an objective evaluation between the environmental problem areas, fits the data available from Region 6 programs, and is compatible with the methodologies used by other regions. The workgroup first reviewed the approaches used by other regions. Region 3 chose to use an existing regional management factor analysis which they did not document. Region 1 evaluated and documented the assessment of management factors whereas only the summary report was available from Region 10. The three regions basically followed the same approach for welfare impacts. The workgroup decided to follow the approach used by Region 1 for management with two changes:

The workgroup believed that the Region 1 evaluation of remediation costs overlapped with the ranking conducted for welfare risks, and decided to group all cost evaluations into the welfare analysis.

The workgroup did not believe that the necessary resources to remediate environmental risk

could be objectively identified, and decided to identify only the existing resources.

The workgroup decided to use each program's knowledge of public perception, resources, technology, and legal authority as the sources of information. The workgroup member from each program was responsible for providing the input for his or her program for these factors. Input from programs not represented on the workgroup was obtained by interviewing the appropriate branch chiefs. The workgroup decided to use the Region external affairs and counsel offices to augment program information on public perception and legal authority. Despite these efforts, most of the evaluation was based upon limited information.

After all the information concerning public perception, legal authority, and effective technology was collected, an initial ranking was made by the workgroup individual assigned to the problem area. @ ranking was then discussed and reviewed by the entire workgroup, and a consensus ranking was developed based on the overall knowledge and understanding of the workgroup.

The workgroup also decided to not combine the rankings for each of the management factors into a single overall ranking. The workgroup members did not believe that a combined ranking would properly reflect the relative weight and/or significance of each factor in the decision--making process.

Results

Public Perception: The workgroup considered the way the public perceives an environmental problem was considered a major factor which influences the Region's response to that problem. The workgroup believed that the higher the public perceived the risk to be, regardless of the accuracy of the perception, the more likely would the Region be able to justify efforts to reduce that risk. The group agree that high public involvement may in some cases make the problem more difficult to control.

As expected, those problem areas associated with toxics, radiation, and pesticides were ranked higher than other areas. This follows the trends reflected in a recent Roper Poll. In addition, program staff ranked nonpoint sources to water as a high public concern; this also reflects to some degree the Roper Poll where 51% of the polled public considered agricultural runoff to be a serious problem.

Legal Authority: Ile workgroup believed that the weaker the legal authority, the less likely could the problem be controlled. This would be a concern to regional managers if the environmental problem area posed a high risk. As expected, the older established programs such as industrial and municipal point sources to water were found to have full legal authority as tested by the courts. Younger programs such as degradation of water and wetlands or nonpoint sources have less authority.

Effective Technology: The workgroup considered the technology and management practices that exist to reduce risk, whether the methods are reliable and efficient, and the proportion of the

problem area to which they are applicable. The less effective the technology, the less the workgroup believed that the problem was controllable by the region's programs and the more concern to regional managers if the environmental problem area posed a high risk.

Most program staff believed that there was some form of treatment or control technology which could abate all environmental problems. Environmental problems related to solid waste, wetlands, and radiation were ranked higher than other areas due to the lower effectiveness of the available technologies.

Available Resources: The workgroup compiled resource information on Fiscal Year 1990 (FY90). Resource data for FY91 was gathered by the Office of Policy and Planning. This information included the number of Full Time Employees (FTE), regional grant and contract assignments for each problem area. The workgroup relied on input from program managers for this information. No comparative rankings were developed because there was no objective way to determine if the resources were adequate to abate the environmental problem.

Conclusions

The Region 6 workgroup believes that the information developed and summarized in Table 14 herein can assist decision makers as they set priorities for control of various environmental problem areas. Each evaluation could be refined if more specific information were available. For example, the public perception factor could be better defined if regional programs routinely compiled all information on public interest, or if there were time to conduct a region-specific poll of public interest groups or the general public.

The comparative risk analysis, like Unfinished Business (1987) and all other EPA and state risk projects to date, has demonstrated that some higher risk environmental problems have less agency resources than several problems judged to be of lower risk. Figures 38 through 41 graphically compare the region's distribution of FY91 FTE, grant and contract dollars to regional ecological and human health risk rankings.

Analysis of Regional resources information shows that 4.7 percent of the Region's cost of full--time employees and contract/grant dollars are committed to ecological problems ranked as high and moderate-high risk. Seven percent is committed to the human health problems ranked in these top two categories. The percentage of resources which are committed to resolving the Region's combined ecological and human health problems in the high and moderate-high risk categories is 9.8 percent. Ninety percent of the Region's resources are utilized to address problems in the moderate-low to lowest risk categories.

Several of the environmental problems ranked in the highest risk categories may not require substantial increases in resources. Opportunities for reduction in human health risks from radon exposure and indoor air pollution can take the form of monitoring of home contaminant levels, public awareness, and educational programs. However, environmental problems such as pesticides application, global warming, hazardous air toxics, stratospheric ozone depletion, and ozone and carbon monoxide pollution may require substantial resource increases and actual life

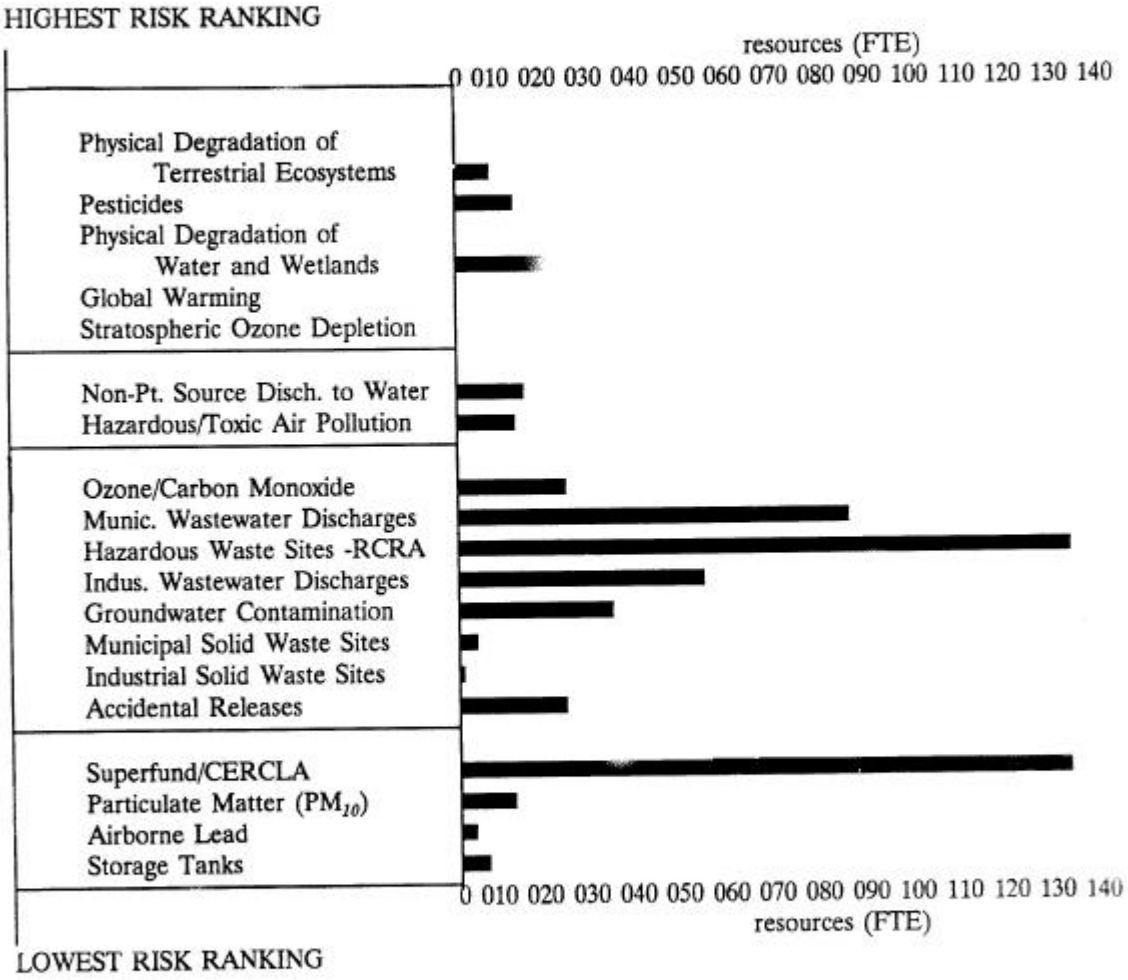
style changes by Region 6 residents. It is also important to realize that reallocation of EPA resources will not necessarily reduce risk proportionally without concurrent commitment to changes in existing laws. For example, many activities that physically degrade wetlands and terrestrial ecosystems are not regulated or are weakly regulated by EPA.

Table 14: Summary of Risk Management Factors
Summary Evaluation Ranking

Environmental Problem Areas	Public Perception	Legal Authority	Effective Technology	FY91 Resources
Industrial Point Sources	5	2	2	5,159,800
Municipal Point Sources	3	2	3	161,879,000
Drinking Water Supplies	4	2	2	6,103,500
Non-point Discharges to Surface Water	3	5	5	5,029,000
Physical Degradation of Water and Wetlands	3	4	5	2,795,000
Aggregated Groundwater Contamination	4	3	3	8,417,500
Storage Tanks	2	3	2	8,029,000
RCRA Sites	4	4	3	21,181,400
CERCLA Sites	5	3	4	90,209,500
Municipal Waste Sites	3	4	3	565,000
Industrial Waste Sites	2	4	3	45,000
Accidental Releases	5	1	3	1,982,000
Pesticides	5	3	3	4,550,500
Air Nitrogen Oxides and Sulfur Oxides	3	3	2	1,700,500
Carbon Monoxide & Ozone	5	4	3	8,570,400
Airborne Lead	3	2	1	1,107,000
Air Particulate Matter	3	2	1	1,775,800
Hazardous & Toxic Air Pollutants	5	4	3	2,490,600
Indoor Air Pollution	3	5	2	162,400
Radon	4	5	2	746,000
Other Radiation	5	3	3	190,000
Physical Degradation of Terrestrial Ecosystems	5	4	3	858,000

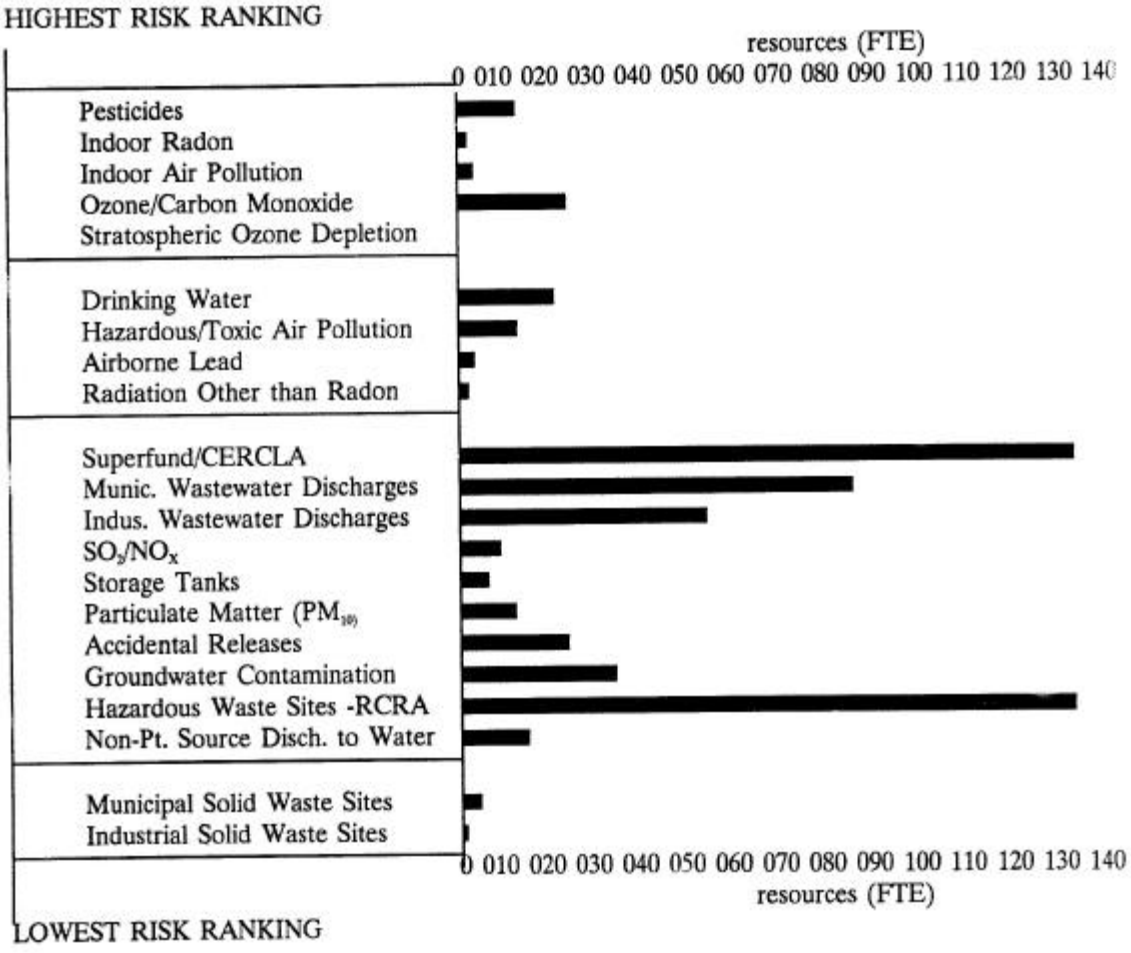
Scale: 5 = of most concern; 1 = of least concern.
Contract and grant dollars and FTEs were combined to present an assessment of the overall resources. FTEs were converted to dollars using a factor of $45,000/FTE.

FIGURE 38
CURRENT DISTRIBUTION OF REGION 6 FY91 FTE
BY PROBLEM AREA / ECOLOGICAL RANKING



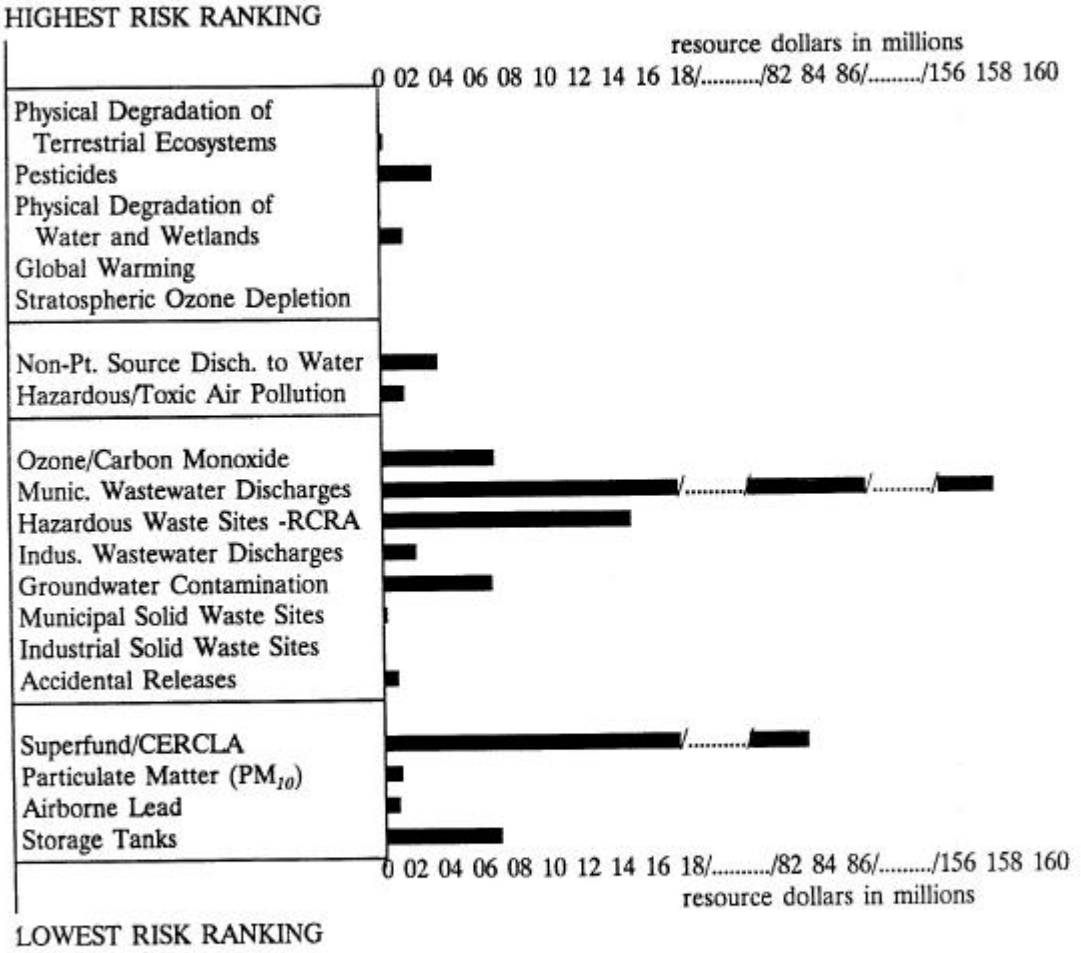
NOT RANKED: Drinking Water, Indoor Radon, Indoor Air Pollution, Radiation other than Radon, SO_2/NO_X.

FIGURE 39
CURRENT DISTRIBUTION OF REGION 6 FY91 FTE
BY PROBLEM AREA / HUMAN HEALTH RANKING



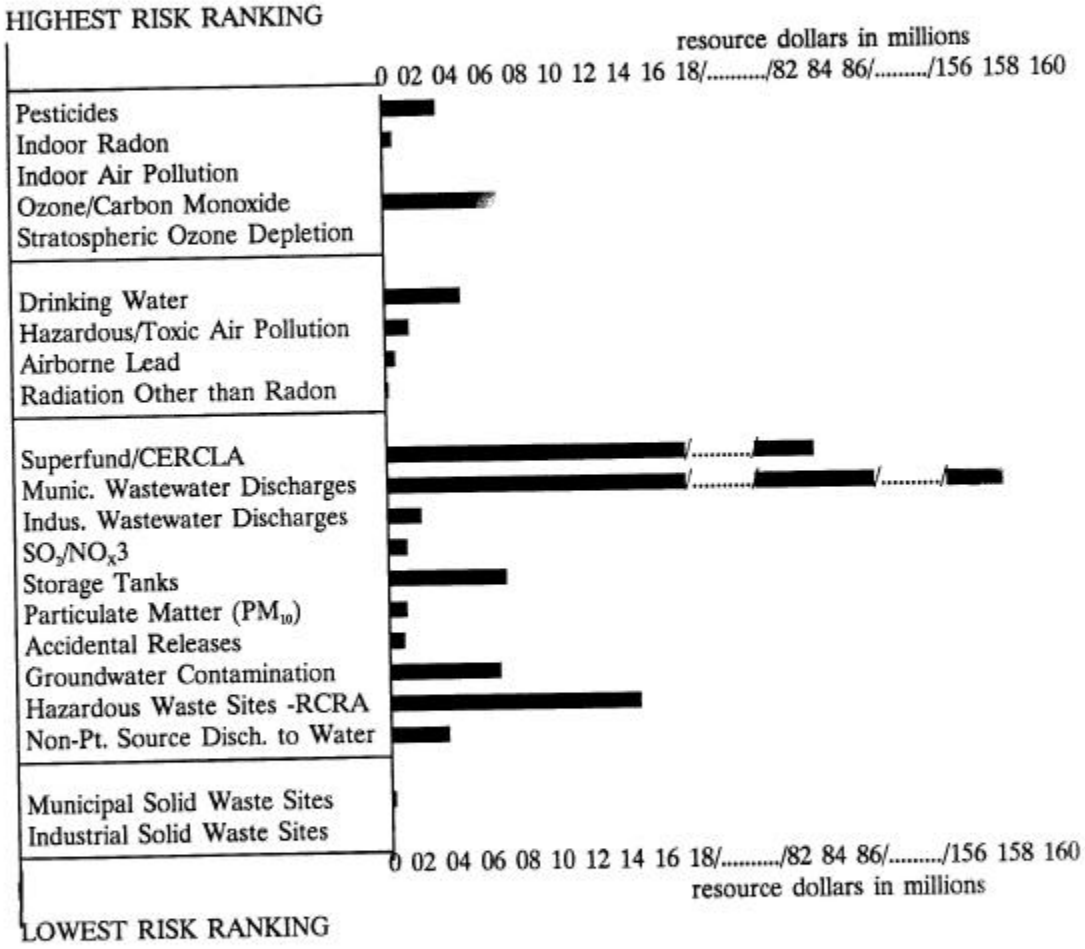
NOT RANKED: Physical Degradation of Water and Wetlands, Physical Degradtion of Terrestrial Ecosystems, Global Warming

FIGURE 40
CURRENT DISTRIBUTION OF REGION 6 FY91 CONTRACT AND GRANT DOLLARS
BY PROBLEM AREA / ECOLOGICAL RANKING



NOT RANKED: Drinking Water, Indoor Radon, Indoor Air Pollution. Radiation other than Radon, SO_2/NO_X

FIGURE 41
CURRENT DISTRIBUTION OF REGION 6 FY 91 CONTRACT AND GRANT DOLLARS
BY PROBLEM AREA / HUMAN HEALTH RANKING



NOT RANKED: Physical Degradation of Water and Wetlands, Physical Degradation of Terrestrial Ecosystems, Global Warming

ECONOMIC REPORT SUMMARY

Industrial Economics, Inc. (IEc) has quantified the economic damages caused by pollutant discharges and other environmental degradation in 25 problem areas. These damages are summarized in the accompanying Exhibit (Tables 15 and 16), Economic Ranking of Problem Areas, which presents a low and high range of annual damages. In general, IEc ranking of these damages is based on the magnitude presented in the table, according to the following scheme:

1 = > $ 500 million
2 = $ 100- $ 500 million
3 = $ 10- $ 100 million
4 = $ 0- $ 10 million

Problem Area #1 - Industrial Discharges: Ranking = 3

Total annual economic damages range from about $4 million to $26 million. Most of these damages are attributable to recreational losses. The range is due to uncertainty about the percent of freshwater and saltwater resources not meeting fishable/swimmable goals. IEc believes that the mid-point of the range is appropriate for ranking. Since the mid-point lies above $10 million, but below $100 million, IEc ranks this problem area as a 3.

Problem Area #2 - POTW Discharges: Ranking = 3

Total annual economic damages range from about $28 million to $77 million. Most of these damages are attributable to recreational losses with a relatively small amount attributable to health damages and commercial harvest losses. The range is due to uncertainty about the percent of fresh water and salt water resources not meeting fishable/swimmable goals. Since the range lies wholly within category 3, IEc ranks this problem area a 3.

Problem Area #3 - Aggregated Drinking Water: Ranking = 3

Total annual economic damages range from about $18 million to $30 million. Health damages due to cancers account for about $13 million and resource damages to groundwater wells account for about $5 million to $18 million. Additional health damages could be due to non-carcinogenic illnesses, which are unaccounted for in this analysis. Likewise, data on numbers of wells replaced each year are highly uncertain. Nevertheless, the damage range is comfortably in category 3, and new data are unlikely to move the damage estimate out of this range. Consequently, IEc ranks this problem area a 3.

Problem Area #4 - Non-Point Source Discharges: Ranking = 2

Total annual economic damages range from about $73 million to $290 million. Most of these damages are attributable to recreational losses with a few million dollars in damages attributable to health damages and commercial harvest losses. The range is due primarily to uncertainty about the percent of freshwater and saltwater resources not meeting fishable/swimmable goals.

Since the range lies mostly above $100 million, IEc ranks this problem area as a 2.

Problem Area #5 - Wetlands: Ranking = 2

Total annual economic damages range from about $92 million to $502 million. There are a significant fraction of the nation's wetlands at risk in Louisiana and the Texas Gulf Coast. These resource damages include losses attributable to commercial fisheries and timber harvests, recreational fishing and hunting, and storm and flood protection. Wetlands also provide some other values, such as enhancement of water quality, that IEc was unable to quantify. The range is due primarily to uncertainty over the value of certain wetland functions and the basis of extrapolating those values to the quantity of resources lost annually. Nevertheless, the damage range for this wetlands problem area is almost identical to the category 2 range.

Problem Area #6 - Aggregated Groundwater: Ranking = 3

Total annual economic damages range from about $18 million to $30 million. Health damages due to cancers account for about $12 million and resource damages to groundwater wells account for about $5 million to $18 million. Additional health damages could be due to non-carcinogenic illnesses, which are unaccounted for in this analysis. Likewise, data on numbers of wells replaced each year are highly uncertain. Nevertheless, the damage range is comfortably in the range of $10 million to $100 million, and new data probably would not move the damage estimate out of this range. Consequently, IEc ranks this problem area a 3.

Problem Area #7 - Underground Storage Tanks: Ranking = 4

Total annual economic damages range from about $0.5 million to $1 million. Health damages due to cancers account for a negligible amount and incidence of other diseases was unavailable for quantification purposes. Most of the quantifiable damage was due to replacement of contaminated wells. However, the data on well contamination are very limited and the estimates presented here could underestimate actual damages. This is clearly an area where more data would be useful. Until additional data provide evidence that greater economic damage is occurring, IEc ranks this problem area a 4.

REGION 6 COMMENTS FOR PROBLEM 7:

The preamble to the Federal underground storage tank regulations sta' that EPA estimates the 30-year costs of complying with the regulations is $70.26 billion, of which $29.29 billion is for performing corrective action for leaking tanks. Since Region 6 has approximately 15% of the Nation's underground storage tanks, this amounts to be annual costs of $351 million to Region 6 for complying with UST regulations, of which $147 million is for performing corrective action for leaking tanks. The Region 6 public also has increased costs in real estate transfers where underground storage tanks are involved, property equity reduction because of g or abandoned tanks, and fees for gasoline transfers of $25 n per year in support of States Petroleum Trust Funds.

These annual costs total at least $175 million for leaking underground storage tanks, and if costs for compliance with UST regulations are included, the annual costs are approximately $400 million in Region 6 and the economic risk rating for underground storage tanks should be 2.

Problem Area #8 - RCRA Hazardous Waste Facilities: Ranking =4

Total annual economic damages amount to about $2 million. Health damages due to cancers account for all the economic damage in this problem area and there appears to be minimal risk of other diseases. There may be some damage due to replacement to contaminated wells, but data are unavailable to measure this loss. Based on the available data, there is little doubt that this problem area ranks as a 4.

REGION 6 COMMENT FOR PROBLEM 8:

Public perception of hazardous waste sites and corporate strategics to limit exposure and liabilities have quantifiable economic impact upon the public. Losses to commercial and residential real estate value due to actual/potential proximity to hazardous waste treatment, storage, and disposal facilities is quantifiable. A trend exists among RCRA facilities to purchase surrounding properties so as to limit their “off site” related exposure/liability. The economic burden of decreased property value and the passed-on costs of corporate strategies to limit liability is ultimately borne by the public. Based on the available data, the ranking should be 1.

Problem Arm #9 - Abandoned/Superfund Sites: Ranking = 4

Total annual economic damages amount to about $4 million. Health damages due to cancers account for about $3 million, and resource damages measured by replacement of contaminated wells account for about $1 million. There appears to be minimal risk of other diseases from contamination from abandoned/hazardous waste sites. Region 6 provided data on the costs of replacing contaminated wells at four Superfund sites, but no exhaustive search was done to determine that these were the only sites where drinking water or irrigation water wells were polluted and remedied. 'Mis damage category could be higher. Nevertheless, based on the available data IEc ranks this problem area a 4.

REGION 6 COMMENTS FOR PROBLEM 9.

Remedies for Superfund Sites in Region 6 range from $1 to $4 billion. These funds obtained from the trust fund or directly from responsible parties, are being expended to obviate between $2.4 and $9.0 billion in projected economic I and the prevent annual expenses if between $30 and $90 million per year.

Problem Area #10 - Municipal Waste Sites: Ranking = 4

Region 6 was unable to provide data on health risks or resource damages to groundwater connected with industrial waste sites. Consequently, IEc's ranking based on the assumption that total annual economic damages are negligible. This assumption could, of course, prove wrong if

data become available. Given negligible damages, IEc ranks this problem area a 4.

Problem Area #11 - Industrial Waste Sites: Ranking = 4

Region 6 was unable to provide data on health risks or resource damages to groundwater connected with industrial waste sites. Consequently, IEc's ranking based on the assumption that total annual economic damages are negligible. This assumption could, of course prove, wrong if data become available. Given negligible damages, IEc ranks this problem area a 4.

Problem Area #12 - Accidental Spills: Ranking =4

Total annual economic damages amount to about $1.4 million to $2.5 million primarily for evacuation damages. This is a particularly difficult problem area to define for the purposes of this comparative risk project. IEc has restricted its analysis to spills or releases that affect the ambient environment and did not consider industrial accidents that are the regulatory responsibility of OSHA- The primary economic damage is associated with accidental releases and spills is the cost associated with evacuating people potentially at risk. There may be some health damage associated with acute exposure to spilled substances, but Region 6 was unable to provide such estimates. The damages associated with these evacuations places this problem area in the lowest category; IEc ranks this problem area as a 4.

Problem Area #13 - Pesticides: Ranking = 3

The estimate for total annual economic damages ranges from $15 million to $373 million. This range of damages is very wide and spans ranking categories 3 and 2. The wide range of damage estimates is due to a very wide range of health damages caused by cancer incidence estimates that range from 177 to 5584 per year. It is IEc's judgment that there is greater uncertainty that the high end of this range is correct. Consequently, IEc feels that the pesticide problem area is more appropriately ranked as a 3.

Problem Area #14 - Sulfur/Nitrogen Oxides: Ranking = 2

Total annual economic damages range from about $198 million to $587 million. This range of damages lies mostly within ranking category 2. Most of these damages are attributable to estimates of visibility degradation calculated by extrapolating contingent valuation studies from eastern cities. IEc took considerable care in applying these studies to. the Region 6 area, considerable uncertainty remains in extrapolating results to an area with substantially better visibility conditions. Uncaptured in this assessment are any damages to materials caused by acidic deposition in urban areas. Despite some uncertainty about the reliability of contingent valuation studies, the range of damages spans category 2, and IEc is feels sulfur/nitrogen oxides should be ranked as a 2.

Problem Area #15 - Ozone/Carbon Monoxide: Ranking = 1

Total annual economic damages range from about $794 million to $882 million. 'Mis range of damages exceeds $500 million and ranks in category 1. Most of these damages are attributable to

estimates of damage to commercial crops from ozone exposures. The estimates of these crop damage in Region 6 come from national models. The national models account for differences in ozone concentrations by region. IEc's estimate of ozone damage in Region 6 was based on proportioning the national damage estimate, by crop, based on Region 6's percentage of crops, by value. IEc believes this approach provides a reliable approximation of the damages. In addition, this problem area accounts for about $50 million in health and materials damages. Thus, IEc believes that this problem area should be ranked as a 1.

Problem Area #16 -Airborne Lead: Ranking = 4

Total annual economic damages range from $0 to about $5.2 million. All these damages are attributable to airborne lead's effect on health. Studies of children near lead smelters provide little evidence of adverse health impacts. More uncertain risk assessments that rely on urban exposures that have been declining with the phase-out of lead-in-gasoline yield annual damage estimates of only about $5 million. IEc ranks this problem area as a 4.

Problem Area #17 - Particulates: Ranking = 2

Total annual economic damages amount to about $854 million. This damage estimate exceeds $500 million and would normally qualify for ranking in category 1. However, most of these damages, about $780 million per year, is attributable to household and industrial cleaning costs. There is some doubt about the methodological reliability of these studies. Moreover, they may be capturing damages associated with naturally occurring dust, which is fairly common in parts of Region 6. For these reasons IEc feels it is appropriate to downgrade the ranking of this problem area to a 2.

Problem Area #18 - Hazardous Air Pollutants: Ranking = 3

Total annual economic damages range from about $16.6 million to about $32.7 million. All these damages are attributable to risks to health damages caused by various carcinogens. There may be other damages from hazardous air pollutants to recreation or natural resources, but quantitative evidence of economic damage is unavailable at this time. Moreover, IEc believes that the magnitude of additional damages would be too small to change this ranking. This range of damage falls wholly within category 3.

Problem Area #19 - Indoor Air Pollutants (Non-Radon): Ranking = 2

Total annual economic damages range from about $187 million to about $278 million. Health damages alone account for about $95 million per year with remediation of buildings containing asbestos and other hazardous materials accounting for the remainder. Estimates of the annual expenditures for remediation are subject to some uncertainty, since they are taken from national estimates. However, health damages alone almost push this problem area into category 2, and additional damages from remediation activities push the range of damage wholly into category 2. As a result, IEc ranks this problem area a 2.

Problem Area #20 - Indoor Radon: Ranking = 2

Total annual economic damages for indoor radon range from about $49 million to about $278 million. Damages in this problem area are all attributable to health risks of lung cancers. There is strong scientific evidence on the relationship between radon concentration and cancer risk. However, there are uncertainties over the population exposed at different radon levels due to incomplete results of state surveys. IEc's damage estimates depend on extrapolating from limited exposure data, but suggest that there are significant health damages. Consequently, IEc feels that it is appropriate to rank this problem area as a 2.

Problem Area #21 - Radiation (Other than Radon): Ranking = 4

Total annual economic damages for radiation (other than radon) range from about $2.7 million to about $19.1 million, which spans ranking categories 4 and 3. Damages in this problem area are all attributable to health risks of cancers. However, the estimate is divided between the risk of cancer due to exposure to ionizing radiation, which accounts for about $2.7 million and exposure to non-ionizing radiation that accounts for $2.7-16.4 million. There is no scientific consensus on the relationship between exposure to nonionizing radiation from electromagnetic fields and risk of cancers. Consequently, I& feels that it is appropriate to discount the weight of the damages attributable to nonionizing radiation, which leads us to rank this problem area as a 4.

Problem Area #22 - Degradation of Terrestrial Ecosystems: Rankings = 4

Total annual economic damages for this problem area range from about $0.4 million to about $7.3 million. Welfare economics evaluates damages on the basis of changes in areas under the demand and supply functions. In many cases changes (which ecologists would find degrading) may result in increased economic value, i.e. conversion of open space to parking lots in growing urban/suburban areas. The one area where human activities clearly resulted in degradation of land was in mining. Evaluation of this problem area resulted in the damage estimates reported above, but the ecological ranking will differ is expected. Based on the economic damages, IEc ranks this problem area as a 4.

Problem Area #24 - Stratospheric Ozone: Ranking = 1

Economic damages for this problem area were annualized from present value damage estimates calculated through the year 2075. The estimates range from about $211 million to about $1717 million. The damages cover two categories: health damages due to skin cancers and cataracts and commercial harvest damages to crops and fisheries. Both categories are significant. Health damages range from $50 million to $1.5 billion depending on the ozone depletion scenario. The low estimate assumes a 4 percent loss in the ozone layer while the higher estimate assumes a 50 percent loss in the ozone layer. The commercial damage estimate ranges from $161 million to $234 million. There is considerable uncertainty in these estimates of commercial damages due to limited data from actual field studies. Nevertheless, there is speculation that potential damage to algae and krill in ocean environments, which are not counted in this analysis, could be large. While the uncertainties in these damage estimates make ranking difficult, I& believes that the

potential for extremely large annual damages necessities ranking this problem area as a 1.

Problem Area #25 - Global Warming: Ranking = 1

Economic damages for this problem area were annualized from present value damage estimates calculated through over a 100 year period. The estimates range from about $341 million to about $3373 million. The damages include damages to commercial harvest of crops and fisheries, damages to resources, including wetlands, beaches, and other coastal lands inundated by sea level rise, and costs of structures to protect populated centers. The estimates reported here make extensive use of national EPA analyses. On a national basis some regions may benefit from global warming, but it is clear that Region 6 with its extensive coastal wetlands and dependence on coastal resources for its recreation and commerce is extremely vulnerable to the consequences of global warming. While the uncertainties in these damage estimates are large, IEc has no doubt that the results of this global experiment will result in large annual damages to Region **6.** Consequently, the problem area is ranked a 1.

Problem Area #26 - Oil Production/Storage/Transport**:** Ranking **=** 3

Total annual economic damages for this problem area range from about $21 million to about W million, a range which lies wholly within category 3. The damage analysis utilized data on marine, estuarine, and on-land oil spills and applied separate damage estimates to each category of spill by location. Since the annual amount spilled seemed to be decreasing since 1978, IEc used estimates based on two different time periods. Data over 10 years yielded the upper bound estimate while data over the last three years yielded the lower bound estimate. The data on amount of oil spilled did not capture all of the smallest spills, but economic studies indicated that small spills resulted in relatively small estimates of damage per gallon spilled. IEc feels comfortable ranking this problem area as a 3.

TABLE 15

EXHIBIT: ECONOMIC RANKING OF PROBLEM AREAS

PROBLEM AREA	DESCRIPTION	ANNUAL DAMAGES LOW ($MM1990)	ANNUAL DAMAGES HIGH ($MM1990)	RANKING
1	INDUSTRIAL DISCHARGES	4.0	25.5	3
2	POTW DISCHARGES	28.2	77.1	3
3	AGGREGATED DRINKING WATER	17.9	30.2	3
4	NON-POINT SOURCE DISCHARGES	73.0	289.9	2
5	WETLANDS	92.0	501.7	2
6	AGGREGATED GROUNDWATER	17.7	30.0	3
7	UNDERGROUND STORAGE TANKS	0.5	1.1	4
8	RCRA SITES	1.9	1.9	4
9	ABANDONED/SUPERFUND SITES	4.4	4.4	4
10	MUNICIPAL WASTE SITES	0.0	0.0	4
11	INDUSTRIAL WASTE SITES	0.0	0.0	4
12	ACCIDENTAL SPILL	1.4	2.5	4
13	PESTICIDES	14.7	372.6	3
14	SULFUR/NITROGEN OXIDES	198.4	586.9	2
15	OZONE AND CARBON MONOXIDE	794.4	882.2	1
16	AIRBORNE LEAD	0.0	5.2	4
17	PARTICULATES	853.7	853.7	2
18	HAZARDOUS AIR POLLUTANTS	16.6	32.7	3
19	INDOOR AIR POLLUTANTS (NON-RADON)	186.8	278.1	2
20	INDOOR RADON	48.5	248.9	2
21	RADIATION (OTHER THAN RADON)	2.7	16.6	4
22	PHYSICAL DEGRADATION OF ECOSYSTEMS	0.4	7.3	4
24	STRATOSPHERIC OZONE DEPLETION	210.7	1716.8	1
25	GLOBAL WARMING	341.0	3373.0	1
26	OIL PRODUCTION/STORAGE/TRANSPORT	21.0	66.4	3

REGION 6 COMMENTS

PROBLEM AREA	DECRIPTION	ANNUAL DAMAGES LOW ($MM1990)	ANNUAL DAMAGES HIGH ($MM1990)	RANKING
7	UNDERGROUND STORAGE TANKS	400.0	1,000.0	2
8	RCRA SITES	1,000.0	12,000.0	1
9	ABANDONED/SUPERFUND SITES	1,000.0	9,000.0	1

TABLE 16

EXHIBIT: ECONOMIC RANKING OF PROBLEM AREAS

PROBLEM AREA	DESCRIPTION	HEALTH DAMAGES LOW ($MM1990)	HEALTH DAMAGES HIGH ($MM1990)	COMMERCIAL DAMAGES LOW ($MM1990)	COMMERCIAL DAMAGES HIGH ($MM1990)	RESOURCE DAMAGES LOW ($MM1990)	RESOURCE DAMAGES HIGH ($MM1990)	MATERIALS DAMAGES LOW ($MM1990)	MATERIALS DAMAGES HIGH ($MM1990)	RECREATION DAMAGES LOW ($MM1990)	RECREATION DAMAGES HIGH ($MM1990)	REMEDIATION LOW ($MM1990)	REMEDIATION DAMAGES HIGH ($MM1990)	AESTHETI LOW ($MM1990)
1	INDUSTRIAL DISCHARGES	1	1							3	25			
2	POTW DISCHARGES	1	1	1	1					26	74			
3	AGGREGATED DRINKING WATER	13	13				18							
4	NON-POINT SOURCE DISCHARGES	5	5	5	7					63	278			
5	WETLANDS					92	502							
6	AGGREGATED GROUNDWATER	12	12			5	18							
7	UNDERGROUND STORAGE TANKS	0	0			0	1							
8	RCRA SITES	2	2											
9	ABANDONED/SUPERFUND SITES	4	4			1	1							
10	MUNICIPAL WASTE SITES													
11	INDUSTRIAL WASTE SITES													
12	ACCIDENTAL SPILL			1	3									
13	PESTICIDES	11	361			0	1			3	10			
14	SULFUR/NITROGEN OXIDES							55	55					144
15	OZONE AND CARBON MONOXIDE	13	13	745	832			37	37					
16	AIRBORNE LEAD	0	5											
17	PARTICULATES	74	74					780	780					
18	HAZARDOUS AIR POLLUTANTS	17	33											
19	INDOOR AIR POLLUTANTS (NON-RADON)	95	95									91	183	
20	INDOOR RADON	48	249									0	0	
21	RADIATION (OTHER THAN RADON)	3	17											
22	PHYSICAL DEGRADATION OF ECOSYSTEMS					0	7							
24	STRATOSPHERIC OZONE DEPLETION	50	1483	161	234									
25	GLOBAL WARMING			20	229	321	3144							
26	OIL PRODUCTION/STORAGE/TRANSPORT					21	66							

PROGRAM REPORT SUMMARY

Region 6 gathered regional risk data for twenty-four defined environmental problem areas (Attachment A). Program staff and managers were asked to write “risk reports”. These reports summarized ecological, human health, risk management, and economic information for comparative risk workgroup members. APPENDIX D: PROGRAM REPORT'S is a collection of these Regional Comparative Risk Project (RCRP) reports.

Program reports became very useful in documenting regional perspective, scientific views, and the important program assumptions used for risk evaluations. The approach allowed the region to develop assessment skills and the organizational structure necessary for risk based decision making processes. The program report method of gathering comparative risk information was an experimental process. For this reason it is appropriate to discuss the methodology, results, and conclusions derived from the exercise.

Methodology / Instructions to Report Writers

Region 6 held to the premise that program staff knew more about the risk posed by specific problem areas and the data to support their risk calculations than any other group. For this reason a representative was identified from each regional program to serve on one of the three comparative risk workgroups and to coordinate the writing of risk reports.

All branch chiefs received a memorandum from the Deputy Administrator requesting staff RCRP contacts to be named. The project director followed this request with an example of a program risk report prepared by the Radon Program Coordinator. The report characterized the estimated risk posed by radon exposure in Region 6. Program staff were asked to write similar reports addressing specific environmental problem areas. Each report was to characterize the associated ecological, human health, and economic risk impacting their programs. The Ecological and Risk Management workgroups issued separate memos with more specific requests. These written communications are presented in Attachment C of Appendix D (Program Reports).

Results

All but a few programs submitted draft Regional Comparative Risk Project reports. No Region 6 program had a risk report or a collection of risk related data that could be easily assembled for comparative risk purposes. Human health information was available but only one program had the experienced personnel to easily draft risk evaluations. The CERCLA (Superfund) program had staff toxicologists trained in EPA risk assessment methodology. Several programs had very capable scientists who were familiar with risk assessment methods through their work with states and from Risk and Decision Making training.

Programs such as Drinking Water, Indoor Radon, Pesticides, Radiation, Wetlands, Terrestrial Ecosystems, and virtually all of the Air programs produced excellent risk reports. The Ecological and Risk Management workgroups did not have as much risk information to write program reports. Data gathering for these workgroups involved classical "raw data” assembly

procedures. The Risk Management workgroup had to utilized the judgement of program managers and regional-senior staff members to make many comparative evaluations. Both workgroups had to design regional methodologies.

Approximately fifty program reports were received. Two reports addressed ecological risk only. The remainder tended to concentrate upon risk to human health in the Region. Risk management reports were generally submitted separately. The reports varied in length and detail from two pages with few calculations to fifty pages with detailed chemical, animal species, demographic, epidemiological, toxicological, or computer assisted mathematical assessments.

Program reports are presented by problem area in the Appendix D: Program Reports document.

Conclusions

The request for individual program risk reports was initially met with a less than enthusiastic attitude by regional staff. This statement is easier to write at this time because in general the reports were very effectively used by the RCRP workgroup members. Not only did the reports offer regional staff an opportunity to express their scientific perceptions, they were the primary source of original data, the analytical methods applied, and most importantly, the assumptions and judgments made by the different programs. Comparative risk studies unavoidably contain major data gaps. When this problem exists, credibility can only be achieved through honest and diligent documentation of methodology assumptions. The program reports provided a signed document reviewed by program management.

IV. OBSERVATIONS AND COMMENTS

ECOLOGICAL REPORT: RECOMMENDATIONS

The Region 6 Comparative Risk Project began in April, 1990. The ecological workgroup was formed with representatives from various program offices with an expertise or knowledge of ecological functions and values. The intent and purpose of the analysis was to evaluate 22 environmental problem areas and relatively rank them on the basis of residual ecological risk. A mathematical model was developed. The methodologies for evaluating ecological risk utilized by Regions 1, 3 and 10 were reviewed and then a more quantitative approach was developed. Evaluation of risk occurred at the ecoregion level (Omernick 1986; Map 1) because:

a. Ecoregions are geographically and ecologically based.
b. Ecoregions could serve as a template for data collection.
c. This approach lent itself well to geographic information system applications.
d. There are a wide variety of ecoregions within the five state region (portions of twenty-five ecoregions).
e. The workgroup was concerned about the general health of the large ecological units recognizable in the landscape.

f. There was a short time frame to complete the initial evaluation of ecological risk.

Recommendations of National Implication

1. To fully evaluate ecological risk the ecological workgroup recommends that techniques be developed to assess, evaluate and communicate ecological risk at several levels, including;

    a) the site specific and/or population specific scale,
    b) the community and/or ecosystem specific scale,
    c) the ecoregion scale, and
    d) the biospheric or global scale.

    In this manner specific discharges or activities can be fully evaluated, for specific discharges or activities may not only have site specific impacts but also contribute to ecosystem, regional and global impacts. Cumulative impact evaluation should not be overlooked, nor should impacts which occur to abiotic components of the environment.

    Risk evaluation techniques should be developed and refined for both chemical discharges and physical modification. Methods for combining and evaluating these diverse problems should also be developed. Once appropriate techniques have been developed, they can then be selected for usage on the basis of the objective of the risk assessment or evaluation.

2. To facilitate development of the aforementioned techniques a meeting that brings together personnel from each Region, that have developed each Region's comparative risk evaluation techniques. The purpose of such a meeting would be to compare and discuss each Region's methodology and to develop better approaches to evaluate comparative ecological risk. This workgroup of regional and headquarters personnel should also define the term comparative ecological risk.

3. A method for economic analysis of environmental risk assessment should be developed in conjunction with the development of an ecological methodology. This could enable managers to directly correlate environmental costs versus environmental benefits through marginal analysis or break-even analysis. Marginal analysis results could then be directly applied and used to justify program disinvestments, and investments during the strategic planning process.

4. The Region 6 approach or a similar modified approach should be used at a national level to evaluate comparative ecological risk. Specifically,

   a) utilization of a mathematical index to evaluate and rank residual ecological risk,
   b) initial evaluation on an ecoregion scale to determine how relative risk is distributed across the country, and
   c) utilization of a geographic information system, to generate maps which effectively communicate the distribution of residual ecological risk nationwide.

5. In using the Region 6 approach or a modified approach, on a national level it is recommended that;

   a) ecological functions be weighted for relative importance, and
   b) ecoregions be weighted for their importance at an interregional or national scale (for instance some regions of the country may have high concentrations of endangered or threatened species or be important to migrating populations).

6. Regions should continue to evaluate comparative residual risk at an ecoregion level but work to acquire databases so specific ecosystems can be identified and located geographically. After adequate databases have been acquired, evaluation at the ecosystem or community level should be performed. An intermediate level of evaluation may exist at a sub-ecoregion level based on vegetative cover type.

7. All Federal natural resource agencies at the Headquarters level should pool their resources to share existing natural resource databases and to identify the location of communities and ecosystems across the country.

8. After comparative ecological risk techniques (recommendation 1) and econometric resource evaluation techniques (recommendation 3) are developed, all Federal natural resources agencies (EPA, USDA, USDI, NOAA, and COE) should combine efforts to;

a) evaluate the ecological risk posed by each environmental problem that each agency regulates,
b) identify programs across all natural resource agencies that could be reduced in scope, increased in scope or combined with other programs, and
c) redirect resources across agency boundaries (if necessary) to maximize environmental risk reduction.

Recommendations for Future Comparative Risk Evaluations

1. Prior to undertaking the next ecological comparative risk project, at least one person per program evaluated needs to be detailed for preparation of specific program reports, obtaining needed databases, evaluating and interpreting data and report preparation. Each individual should be detailed for 120 days. Contract support for computer programming, map preparation and typing should also be available when the risk evaluation effort begins.

2. Databases for groundwater and storage tank problems should be further developed to allow for future evaluation by the mathematical index specifically, the areas of impact for each of these problems, to non-human populations needs to be identified.

3. The scope of problems evaluated needs to be expanded to include oil and gas discharges, water toxic discharges, near coastal waters issues, and the Gulf of Mexico.

4. The impacts to aquatic and terrestrial organism production in the Western Gulf Coastal Plain and Mississippi Alluvial Plain need to receive an increased weighting value. This is necessary because these two ecoregions provide wintering habitat to large concentrations of wildlife which spend major portions of their lives in other ecoregions. Consequently, an impact in these two areas is likely to go beyond ecoregion boundaries.

5. Associated with recommendation 3 is the need to expand the definition of the vulnerability indicators for terrestrial and aquatic organisms, to include important keystone or indicator species, in addition to endangered species.

6. The mathematical model needs to be re-evaluated to determine whether separate intensity and duration variables are needed. The model also needs to be evaluated to determine whether a reversibility variable needs to be added, or used to replace the vulnerability variable.

7. A decision needs to be made by the next workgroup to determine whether any of the ecological functions should be weighted for purposes of calculating risk index values.

8. The location of unique biological areas or communities needs to be identified through accessing of:

   a) the National Wetland Inventory, or
   b) the State heritage program databases.

   If possible, these databases should be obtained in a digitized format and entered into the Region's geographic information system.

9. Databases in each of the programs need to be collected or developed on an ecological basis, whether it be by ecoregion or community type, for both aquatic and terrestrial regions or communities.

10. The Region needs to seek input from state and local natural resource agencies in future years, to access state wide and localized databases, and obtain their input.

General Recommendations

1. In past years the Council of Environmental Quality has produced Environmental Trends, a national perspective of the state of the environment. Although the document gives insightful national trends, it is not specific enough to apply the findings to the Agency's programs or regional problems. A regional "State of the Environment" report should be generated to continue to track the state of the regional environment. This report may or may not utilized in future ecological risk analysis.

2. Research is needed to identify indicator or keystone species. Research is also needed to investigate the assimilative capabilities of various community types and study the impacts of chemical discharges or whole communities. In this manner, preserve the health of ecosystems as well as individual species can be preserved.

3. Ecological risk can be evaluated at the county level using the existing method by simply changing the area of ecoregion to area of county (A_c) and imputing data for the other variables as currently defined. In this scenario, a matrix score sheet needs to be developed for each county instead of one for each ecoregion. The area of impact will also only reflect area of impact within each county not each ecoregion.

4. Ecological, risk management and health risk values can be combined in future mathematical index models, if desired to create a combined risk index ranking.

5. The risk associated with specific chemicals can also be evaluated and portrayed graphically, through modification of the existing methodology.

6. Results from this risk evaluation can be used for targeting agency enforcement, permitting and grant activities.

7. Large-scale problems, such as pesticides, physical degradation of water and wetlands, physical degradation of terrestrial ecosystems, non-point source discharges, and groundwater contamination need to be addressed comprehensively through sustainable agriculture initiatives or studies.

HUMAN HEALTH REPORT: OBSERVATIONS AND COMMENTS

Through participation in the Regional Comparative Risk Project, the workgroup learned more about Regional programs and the human health risks addressed through these programs. More importantly, the workgroup developed an appreciation for differences among the programs regarding risk and the difficulty in applying a single, consistent risk methodology to all problem areas. In this section, the workgroup presents a few general observations regarding the comparative risk project. These observations are offered to improve the methodology by which the ranking **process** is conducted. Future workgroups can benefit from the foundation of the
1990 health risk ranking process.

1. The data available and amenable to risk assessment varied greatly among the problem areas. Concentration and/or population data to adequately assess risk was often limited or non-existent.

   In many programs, data for problem areas may have existed, but retrieving the data from files and converting the data to a form useful in risk assessments would have taken months of searching, compilation, and modification. In future iterations of the risk project, more resources should be expended in retrieving data from program files and developing data that currently may not exist. Additional resources should also be expended in reviewing and assimilating state databases into the risk project. Environmental and health data bases of other federal agencies should also be accessed.

2. The non-carcinogenic ranking was difficult because of the subjectivity of the methodology. The scales used to measure populations affected and the severity of health effects could be considered arbitrary. The carcinogenic methodology was considered much more objective in that the assumptions used in the risk equations were backed by research data. This subjectivity was even more apparent in combining the cancer and non-cancer rankings.

   The development of a mathematical model to generate a single non-carcinogenic risk number for each problem area would be most useful in eliminating the subjectivity in the rankings. Ultimately, a single model incorporating carcinogenic and non-carcinogenic risks should be developed for use in the ranking process.

3. The use of "natural breaks" in the carcinogenic incidence (Table 3) worked well. The cancer risks from each problem area grouped themselves very nicely by orders of magnitude providing very good definitions for the categories used in the ranking process.

4. Programs reported data differently. Regulatory programs reported data by indicating that a standard had been exceeded, but not necessarily by the magnitude of the exceedance. In order to adequately assess risks, the magnitude and duration of the exceedance should be reported.

5. The level of existing controls varies from program to program. The exceedance risk level to be achieved by a program or a standard was not consistent. In order to appropriately compare risks from one problem area to another, a single target risk level should be set. A comparison of the degree to which each problem area exceeds this single target may be a more valid comparison

of risk.

6. Adherence to the workgroup's third ground rule that the RCRP would consider average, not worst case exposures was difficult. This was because the risk assessment methodologies used in the human health calculations are conservative, and inherently provide worst case assumptions. This inconsistency should be addressed in future approaches.

7. The pharmacokinetics of specific toxicants was not evaluated for many of the specific pollutants identified. Clearly different classes of compounds posses specific toxicological potencies dependent on their chemical form. The polar nature of many acids, bases, and salts, and certain metal compounds make them less able to translocate into human cells when compared to lipophilic organic and halogenated organic compounds. Future human health assessments will address this important area I of toxicology.

8. The environmental half-lives of organics, halogenated organics, and metals are generally very long in comparison to half-lives for acids, bases, salts, and other nonorganics and non-metals. Therefore, the potential for human exposure is often higher for the former compounds.

9. Stratospheric ozone depletion, and ozone/carbon monoxide were problem areas ranked in the highest combined risk category by the Human Health workgroup. The source for these three environmental problems is primarily releases of hazardous/air toxics. Most of the compounds released to air have more potential for human toxicity than those chemicals released to other media. The basic chemistry of these compounds lend themselves more to absorption and distribution in human body tissues. -Air is chemically considered an abiotic (without life) media, therefore the opportunity for biological transformation of air toxins to less toxic forms (enzymatic oxidation, conjugation, sulfation) is negligible. Soil and water have this biological opportunity. Transformations which do occur in air (i.e., photo-oxidation, hydrolysis) often produce compounds with specific toxicities of their own (i.e., 1,3-butadiene is oxidized to the carcinogen formaldehyde and the respiratory irritant acrolein).

10. TRI data indicates that the Region's releases to ambient air included many organics and halogenated organics with long environmental half-lives. These compounds can be released from any media (from discharges to water, accidental chemical spills, hazardous waste sites). Most air toxics exposures are via the inhalation route. The lungs are one of the fastest and most accessible routes for entry of toxins to the human blood stream.

11. It was very important to Region 6 that program staff author risk reports as well as gather and interpret data for the RCRP. The Region can build upon the work completed in 1990 only if risk expertise is developed within each program and ownership is established among staff scientists. The human health workgroup was able to compare different approaches and assumptions. Members are now able to look at all the approaches and begin to consider “normalizing” assumptions and regulatory standards. This is essential before meaningful comparative risk analyses can occur (i.e., between Drinking Water and Hazardous/Air Toxics.)

12. EPA data bases need to undergo quality assurance evaluations. The task may be too large Agency wide, but cross-media projects such as the RCRP can serve to begin the process for a defined number of data fields (i.e., latitude and longitude, exceedance information, chemical identification). This was selectively performed for Regional TRI data and also for the Public Water Supply, and NPDES systems.

13. A stringent criteria for assessment of uncertainty should be developed. The total number of animal studies, worker exposure case studies, epidemiological studies, and other scientific papers appearing in specific medical data systems for identified compounds could be used as a measure. Other quantitative measures could be the extent of monitoring performance for different programs. The analytical sensitivity, the number of sites monitored, and knowledge of background levels for specific pollutants (i.e., chromium in soils, carbon monoxide in urban environments) could all be used in a coordinated assessment of uncertainty.

14. Risk assessment for exposure to EPA identified carcinogens is the only peer reviewed and program applied risk methodology which is available to comparative risk scientists. The credibility of these risk studies will be discounted until methodologies addressing non-cancer effects, combining of cancer and non-cancer rankings, and assessment of uncertainty are developed. This needs to be a priority for EPA.

    The Agency must have these established risk methodologies before its scientists can confidently present comparative risk findings to academia, -.the public, and environmental groups.

15. Human toxicology has historically relied upon animal studies to predict possible hazards, to determine exposures of concern, and for insight into biochemical mechanisms of action. The planned use of animal data by the Environmental Monitoring and Assessment Program should be of special interest to human toxicologists. Comparative risk information can be used to help select chemicals of concern to ecology and human health scientists for use as biological indicators.

16. Large variations exist among frequency and methods of ambient monitoring for different media (i.e., air monitoring for ozone/carbon monoxide is hourly under the NAAQS program, water monitoring can be monthly or in some instances, yearly.) Comparative risk information can identify specific pollutants and locations for more efficient ambient monitoring.

17. The Science Advisory Board's report recommended that EPA "attach as much importance to reducing ecological risk as it does to reducing human health risk." To address this recommendation an assessment of the impact of man's technology upon regional ecology needs to be performed. A critical review of agricultural, industrial, transportation, and urbanization activities is necessary before a full understanding of environmental problem areas can occur. Human ecology must be defined and incorporated into human health, ecological, and economic comparative risk methodologies.

RISK MANAGEMENT / ECONOMIC **REPORT: OBSERVATIONS AND** COMMENTS

Ranking the twenty-two problem areas was more subjective for risk management than for other risk categories (ecological, human health, economic). The workgroup had to rely upon professional judgement rather than using a more quantitative approach. In keeping with the overall theme of the Region's comparative risk study, the workgroup relied upon each program to submit risk management information. From that approach the following observations and comments are noted.

1. Generally, each program judged public perception, legal authority, and available technology in the higher concern ranges for problem areas relevant to their programs. In contrast, problems related to other programs were usually ranked lower. This was determined when managers ranked all the problem areas after an initial evaluation where program staff ranked only their "own" problem areas.

   Although this outcome was not a surprise, it was of analytical benefit to the workgroup. It was obvious that future risk management methodologies must have more quantitative end points before a significant amount of bias can be eliminated.

2. Quantitative end points are abundant in the Region for the analysis of risk management factors (public perception, legal authority, and available technology). The Risk Management workgroup defined management criteria and designed a methodology which can easily accept quantitative risk management data. Each end point and source would require an analysis as to its appropriateness. Some of these endpoints are discussed below.

   Public Perception

   There are several regional sources of public perception information available. Each source must be defined as to which 'public" it represents. Freedom of Information (FOI) requests, news media and public information requests from External Affairs and Divisional offices, local newspaper articles and television time, controlled correspondence submissions to R6 programs, number and types of public meetings and presentations given by Regional staff, and the number of news releases issued each year are a few of these sources. What is presently missing in the Region is a coordinated documentation of the data from these sources.

   Program specific types of information requests, the subject or purpose of the request, the requester, and which programs respond are all data presently being recorded. The workgroup did not have the time or resources to compile this "public perception" oriented data for the 1990 RCRP report.

   Interviews with individuals in the Region who routinely respond to the public suggests that most formal information requests concern land and water issues, media with high regulatory authority, and are primarily economic and legal based inquires. These requesters may not be the "true public". If this is the case, and the Region allocates a significant amount of resources to gather, interpret, and send the requested information; Regional managers could benefit from understanding what 'public" the Agency actually responds, who speaks to which public, and how

much time and money is expended in the process.

There are several avenues by which the Region responds to the "public". It would also be of managerial interest to know just how the "true public" contacts EPA, Is it a telephone call, a letter to the Administrator or a Congressman, or an FOI request? Only a program wide documentation process can give the Region this information.

The Regional Office of Planning and Analysis should design a system to gather and organize this information.

Legal Authority

A process to coordinate the documentation of not only the number of legal actions taken in the Region but also the type of action (i.e. civil, criminal), the number of legal processes taken, (i.e. depositions, court cases), the source of the activity (i.e. EPA, citizen, or industry initiated), and the legal outcome is essential to evaluating the legal status and history of the problem areas. The Agency's actual "legal authority" can therefore be more quantitatively measured. Again, this information is available to the Region but, has not been compiled for risk management ranking purposes.

Effective Technology

Industry specific information regarding process technologies can be found in Toxic Release Inventory reports. These reports also require the companies to report the effectiveness of their pollution prevention activities. This data added to documentation from Regional programs regarding success or failure of specific technologies (numbers) can be used for this analysis.

3. Information concerning program resources such as FTE utilization, grant and contract funds were difficult to obtain in some programs. Available resources is an important risk management factor and is essential to the strategic planning process. This report contains FY91 resource data for program elements and problem areas. Comparisons of resource data to the ecological and human health risk rankings are presented in Figures 38 through 41 (pp. 130-133). This RCRP has demonstrated, like Unfinished Business, that our administration of resources do not always match our assessment of risk.

4. Economic analysis should be performed by EPA staff. Region 6 did not have sufficient staff with economic expertise to perform a welfare analysis in the time required. It may be possible to perform such studies with existing staff now that Industrial Economic, Inc. has completed the risk report for 1990.

5. Region 6 believes that an economic analysis of the problem areas was very beneficial to both staff and managers. Many of the high ranked economic problem areas were similar to those in the high rank groupings for human health. Indoor Radon, Indoor Air Pollution, Ozone/Carbon Monoxide, and Stratospheric Ozone Depletion were five problem areas which shared either a category 1 or 2 ranking by both economic and human health rankings (5 out of 9 were the same).

Economic ranking similarities with the Ecological workgroup's analysis for the two highest risk groups were Physical Degradation of Water and Wetlands, Global Warming, Stratospheric Ozone Depletion, and Non-Point Source Discharges to Water (4 out of 9 were the same). Also, some problem areas were ranked high by two workgroups but for different risk reasons. For example, Ozone/Carbon Monoxide was ranked in Category 1 in human health because of the large 'at risk" populations in the Region, the severity of the health effects, the available ambient monitoring information, and the confidence in the toxicology data. Ozone/Carbon Monoxide was ranked in the highest risk category economically because of agricultural risks, not as much for human health effects. Particulate Matter (PM_{10}) was ranked high in the economic evaluation largely because of clean-up costs. These differences in reasoning was also a factor in the workgroup's decisions not to combine the ecological, human health, and economic risk rankings.

6. Region 6 should continue to analyze ecological, human health, and economic comparative risk findings to determine why there are similarities in relative rankings, what data was used for each evaluation, and what assumptions were made.

7. The economic methodology and analysis does not appear to be adequate for the assessment of long term losses to natural resources. It would be difficult for the economic analysis to capture the effects from the loss of terrestrial ecosystems or the future impacts of leaking underground storage tanks, hazardous waste site contamination, and bioaccumlation of pesticides. It is the responsibility of Region 6 scientists to bring attention to these limitations and be ever vigilant against misinterpretation of economic concerns. For example, it appears that the destruction of terrestrial habitats for housing, airports, and highways could be an economic benefit to society in the short term. It is certainly not of any environmental benefit when impacts upon biological diversity and the general disruption of natural ecosystems are considered.

8. Methodologies, limitations, perceptions, and assumptions for economic analysis are inherently more aligned with human welfare and urbanization factors than protection of natural ecosystems. However, it is also true that the region's economy and health are significantly affected by the environment. For these reasons, economic analyses are essential to comparative risk studies because they are an integral part of our understanding of human ecology (how man's activities impact the environment and how he is impacted by the environment).

PROGRAM REPORTS: OBSERVATIONS AND COMMENTS

Risk based decision making may result in fundamental changes in the way EPA Region's view their allocated parts of the world. The seemingly simple task of gathering information made staff scientists acutely aware of new skills to be learned, scientific practices to be institutionalized, and a Region wide structure that must be developed. The following list of observations and comments may serve as recommendations for continuing comparative risk studies in Region 6.

Regional report writing created a sense of ownership, purpose, and scientific responsibility among those collecting and interpreting program risk data.

Most scientist were enthusiastic about evaluating relative environmental risk. The task required inter-program and cross media communications which was often a first time experience for many staff members.

Knowledge of EPA risk screening and assessment methodologies was essential to the writing of program reports.

Investments made by Region 6 in the training to staff in Risk and Decision Making, Community Right-to-Know Risk Screening, risk communication, and general toxicology in the past two years was important to the success of the RCRP. Comparative risk can easily become a part of these training programs.

The scarcity of ecological risk data resulted in few program reports addressing ecology.

Regions have little ecological data applicable to comparative risk studies. Region 6 developed a ecological risk methodology which utilized the available regulatory data, is adaptable to changes in data, and can be expanded to incorporate human health, economic, and even risk management information.

Regional specific data for public perception evaluation was not available.

At present records regarding the number of inquiries, sources, and specific questions from the public are not being analyzed in the Region. This could be important information for the efficient management of risk.

Regional programs used very different assumptions in calculating risk evaluations.

Estimating "at risk" populations from a lead smelter was assumed to be the number of residents in a 2 kilometer radius around the site. The at risk populations around a monitor indicating presence of airborne benzene was assumed to be 4 miles. Ozone and carbon monoxide ambient monitoring is performed hourly every day of the year. Ambient monitoring for drinking water supplies is generally performed annually (more often if exceedances are found). Differences such as these require normalization of basic risk assumptions.

The risk reports prepared by programs for the RCRP were the First regional risk specific evaluations produced by most programs.

Region 6 technical staff are finding the reports to be an effective means of technical/scientific communication. The documents can also serve to document program specific biological indicators and environmental assessment information.

Computerized data collection and risk calculations are quite feasible and are planned **for future risk evaluations In Region 6.**

The gathering of risk information in an EPA Region is a very resource intensive task. Region 6 has pioneered a methodology utilizing a computer program to calculate relative risk "index values" (APPENDIX A: ECOLOGICAL REPORT). These relative values can be used to compare specific environmental locations within the Region or to compare problem areas as to which may poses the greatest environmental risk. It is possible to electronically select risk specific data from regulatory databases. Development of such a system would serve to not only institutionalize the risk assessment process in the Region but would establish a ver-y resource efficient method of risk data gathering and analysis. The program could easily be displayed on the Geographic Information System (GIS) which is common to all Regions.

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ATTACHMENT A

Revised Core List of Environmental Problem Areas for Regional Comparative Risk Projects

Problem Areas

1. Industrial Wastewater Discharges to Oceans, Lakes, and Rivers

These are sources of pollution that discharge effluents into surface waters through discrete conveyances such as pipes or outfalls. This problem area does not include publicly and privately owned municipal wastewater discharges. Pollutants of concern include total suspended solids; BOD, toxic organics, including pthalates and phenols; toxic inorganics such as heavy metals; and thermal pollution. Typical sources of discharge include metal finishing, pulp and paper processing, and iron and steel production. Facilities requiring permits under the National Pollution Discharges Elimination System (NPDES) fall under this problem area.

2. Municipal Wastewater Discharges to Oceans, Lakes, and Rivers

This problem area includes all constituents of the outfalls of publicly and privately owned treatment facilities. Both municipal sewage treatment outfalls and industrial discharges that flow through publicly operated treatment works are included in this problem area. Major contaminants include all those found under Industrial Wastewater Discharges to Oceans, Lakes and Rivers, plus ammonia, chlorination products, and nutrients. Combined Sewer Overflows (CSO's) are included in this problem area.

3. Aggregated Public and Private Drinking Water Supplies

As drinking water arrives at the tap, it may contain a wide variety of contaminants from both natural and man-made sources, and point and non-point sources. Since many of the contaminants can be traced to other problem areas, Drinking Water risk evaluation will involve much double-counting with those other problem areas (Industrial Wastewater Discharges, POTW Discharges, Non-point Source Discharges, Storage Tanks, hazardous and non-hazardous waste problem areas, etc.). Drinking Water is included as a problem area because remediation/ treatment options can occur either at the source of contamination (the other problem areas) or at the delivery system of the drinking water (treatment or switch to alternative supplies). Drinking Water includes both delivery systems that serve 25 or more people and are therefore covered by the Safe Drinking Water Act, and those which serve fewer than 25 people and are not so covered. Pollutants of concern include disinfection byproducts, pesticides, inorganics (such as heavy metals), radionuclides, toxic organics, fluoride from natural -.sources, and microbiological contaminants.

4. Non-point Source Discharges to Oceans, Lakes, and Rivers

Non-print Source Discharges include pollutants that reach surface waters through sources other than discrete conveyances for effluents. This includes runoff from agricultural, urban, industrial, silvicultural, or undisturbed land. Possible pollutants are quite varied, although they include

most of constituents of the point source discharges to surface waters.

Storm water carries a large amount of solids, nutrients, and toxics. Other sources included in this problem area arc surface discharge of septic tanks, contaminated in-place sediments, air deposition of pollutants (except for acids), and mine drainage. Pollutants not included in this problem area are acid deposition, solid waste disposal, hazardous waste sites (RCRA & CERCLA), pesticide runoff, and physical impacts from discharges of dredge and fill material.

5. Physical Degradation of Water and Wetland Habitats

Damages arising from alterations in the quantity and flow patterns of ground water and surface water are included in this problem area. Such disturbances include channelization, dam construction and operation, surface and ground water withdrawals, construction and flood control, irrigation distribution works, urban development and the disposal and runoff of dredge and fill materials. Physical changes to water flow and aquatic habitats are included in this I problem area, as is chemical contamination resulting from physical changes (e.g. dredging of contaminated sediments).

6. Aggregated Ground-Water Contamination

All forms of ground water pollution, including sources not counted in other problem areas, compose this problem area. These include fertilizer leaching, septic systems, road salt, all injection wells, non-waste material stockpiles, pipelines, irrigation practices. The list of possible contaminants is extensive and includes nutrients, toxic inorganics and organics, oil and petroleum products, and microbes. As with drinking water, there is much double-counting in this problem area. It is included as a separate "special" problem area like drinking water because a true understanding of the overall risks to this resource is particularly important, and because such an understanding is difficult if the risks re split between many different problem areas.

7. Storage Tanks

Storage Tanks includes routine or chronic releases of petroleum products or other chemicals From tanks that are above, on or underground, tanks owned by farmers, fuel oil tanks of homeowners, or other storage units (such as barrels).

Stored products include motor fuels, heating oils, solvents and lubricants that have air emissions or can contaminate soil and ground-water with such toxics as benzene, toluene, and xylene. This category excludes hazardous waste tanks. Acute releases (explosions, tanks collapse) are examined under Accidental releases.

8. RCRA Hazardous Waste

This category generally includes the risks posed by active and inactive hazardous waste sites regulated under the Resource Conservation and Recovery Act (RCRA). These sites include RCRA open and closed landfill and surface impoundments, hazardous waste storage tanks,

hazardous waste burned in boilers and furnaces, hazardous waste incinerators, and associated solid waste management units. See page and routine releases from these sources contaminate soil, surface water, groundwater, and pollute the air. Contamination resulting from waste transportation and current illegal disposal are also included. Radiation from hazardous “mixed waste” from RCRA facilities included in this problem area.

9. Hazardous Waste Sites -- Abandoned/Superfund Sites

This category includes hazardous waste sites not covered by RCRA, but by Superfund. Most are inactive and abandoned. Sites can be on the National Priority List (NPL), deleted from the NPL, candidates for the NPL, or simply be noted by the federal government or states as unmanaged locations containing hazardous waste. Sites may contaminate ground or surface water, pollute the air, or directly expose humans and wildlife. There are many pollutants and mixtures of pollutants, including TCE, toluene, heavy metals, and PCB'S. Radiation from hazardous “mixed waste” in abandoned/Superfund sites is included in this problem area.

10. Municipal Solid Waste Sites

Municipal waste sites includes open and closed municipal landfills, municipal sludge and refuse incinerators, and municipal surface impoundments. These sources can contaminate ground and surface water and pollute the air with particulates, toxics, BOD, microbes, PCDFS, PBBs, and nutrients. Contamination may occur through routine releases, soil migration or runoff. Most sites are regulated under Subtitle D. This category excludes active and inactive hazardous waste sites.

11. Industrial Solid Waste Sites

Industrial waste sites includes open and closed industrial landfills, industrial sludge and refuse incinerators, and industrial surface impoundments. These sources can contaminate ground and surface water and pollute the air with particulates, toxics, BOD, microbes, PCDFs, PBBs, and nutrients.

Contamination may occur through routine releases, soil migration or runoff. Most sites are regulated under Subtitle D. This category excludes active and inactive hazardous waste sites. Although the list of potential contaminants is similar to municipal solid waste sites, the concentrations, volumes, and mixes of pollutants found on typical sites are frequently very different.

12. Accident Chemical Releases to the Environment

Contaminants are accidentally released into the environment in a variety of ways during transport or production. An industrial unit may explode and emit toxics into the air, a railroad tank car may turn over and spill toxics into surface water or roads, or a ship may run aground and spill oil or other cargo into the environment. Dama es to property, personnel, and wildlife may occur from intense, short term releases of toxic or flammable chemicals. Acids, PCB's, ammonia,

pesticides, sodium hydroxide, and various petroleum products have been accidentally released.

13. Pesticides

This problem area addresses risks arising from the application, runoff, and residues of pesticides to humans and the environment. It includes risks to people applying agricultural pesticides, including farm workers who mix, load, and apply them. Also included are risks to the public and non-target plants and wildlife as a result of short range drift, overspray, and misuse. Some of the more dangerous substances include ethyl parathion, paraquat, dinoseb, EPN, aldicarb, and diazinon. Disposal of mixed pesticide wastes has resulted in the generation of highly toxic, largely unknown byproducts that have entered the air and caused serious health problems. Suburban spraying of property, often done with high pressure systems, can result in contamination of neighboring property, residents, pets, and livestock. Aside from direct exposure, additional pesticide risks stem from exposure through ingestion of residues on foods eaten by humans and wildlife. Bioaccumulation and food chain effects are also included in this category. Note that accidental released, groundwater contamination, and indoor air pollution from pesticides are respectively included in Accidental Releases, Aggregated ground water, and Indoor Air problem areas.

14. Sulfur Oxides and Nitrogen Oxides (including Acid Deposition)

Sulfur Oxides and Nitrogen oxides cause a wide variety of primary and secondary effects. Primary effects include health, visibility, and welfare impacts. A major secondary effect is acid deposition, which results from chemical transformation of oxides of sulfur and nitrogen, producing acid rain, snow, and fog, as well as dry deposition. Acid deposition alters the chemistry of affected aquatic and terrestrial ecosystems, damaging plant and animal life.

Sources are a wide variety of industrial, commercial, and residential fuel and related combustion sources. This problem also includes visibility effects resulting from the long range transport of sulfates.

15. Ozone and Carbon Monoxide

Ozone and carbon Monoxide are major air pollutants in many areas, arising from both mobile and stationary sources. Damage to forests, crops, and human health can be severe. Note that volatile organic compounds (VOC's) are critical precursors to ozone formation, but the direct effects of VOC's are included in the Air Toxics problem area. To the extent that VOC's result in ozone, those ozone effects are captured by this problem area.

16. Airborne Lead

Air emissions of lead result from many industrial and commercial processes. This problem area includes both direct exposure to airborne lead and exposure to deposited lead from airborne sources. It does not include exposure to lead from drinking water delivery systems, or lead found in homes and buildings from leaded paint.

17. Particulate Matter

Both total suspended particulates and fine particulates/PM_{10} are included in this problem area. Major sources include motor vehicles, residential fuel burning, industrial and commercial processes, and in some cases strip or open pit mining.

18. Hazardous/Toxic Air Pollutants

This problem area covers outdoor exposure to airborne hazardous air pollutants from routine or continuous emissions form point and non-point sources. Pollutants include asbestos, various toxic metal (e.g., chromium, beryllium), organic gases (benzene, chlorinated solvents), polycyclic aromatic hydrocarbons (PAHs, such as benzo(a)pyrene, primarily in particulate form), gasoline vapors, incomplete combustion products, airborne pathogens, cooling towers, and a variety of other volatile organic chemicals and toxics.

The problem area covers exposure through both inhalation and air deposition of these pollutants to land areas. Runoff of deposited pollutants to surface waters is addressed in Nonpoint Sources. Major sources include large industrial facilities, motor vehicles, chemical plants, commercial solvent users, and combustion sources. This category excludes, to the extent possible, risks from pesticides, airborne lead, radioactive substances, chlorofluorocarbons, emissions from waste treatment, storage and disposal facilities; storage tanks, and indoor air toxicants.

19. Indoor Air Pollutants Other Than Radon

This category applies to exposure to accumulated indoor air pollutants, except radon, primarily from sources inside buildings and homes. These sources include unvented space heaters and gas ranges, foam insulation, pesticides, tobacco smoke, asbestos, carbon dioxide, carbon monoxide, nitrogen oxides, lead, pesticides, and numerous volatile organic chemicals such as benzene and formaldehyde. Occupational exposures are included, as is inhalation of contaminants volatilized from drinking water.

20. Indoor Radon

Radon is a radioactive gas produced by the decay of radium, which occurs naturally in almost all soil and rock. Risks occur when radon migrates into buildings through cracks or other openings in the foundation, water, or fuel pipes. The gas is trapped by dense building materials and can accumulate to very high levels. When inhaled, radon decay products can cause lung cancer. This category includes radon volatilized from domestic water use, and also includes occupational exposures. The problem area does not include outdoor radon.

21. Radiation Other Then Radon

Exposure to ionizing and non-ionizing radiation (beyond natural background) is included here. Sources of radiation included in this category are: radio frequencies (also T.V. transmitters, power lines, radar, microwave transmissions, and radiation from home appliances and wiring);

radiation from nuclear power operations; high-level radioactive waste (including spent reactor fuel) and low-level waste (including radio-pharmaceuticals and laboratory clothing form hospitals involved in nuclear medicine, tools used in cleaning up contaminated areas, etc.); and residual radioactivity (including the decommissioning of facilities such as laboratories and power plants that use radioactive materials. Also included in this category are industrial processes such as uranium mining and milling, and the mining of phosphates

Radiation resulting from nuclear accidents where radioactivity is released is included under Accidental Releases. Medical exposures (X-rays, radiation therapy) and exposure from ozone depletion are not included.

22. Physical Degradation of Terrestrial Ecosystems/Habitats

Sources affecting terrestrial ecosystems/habitats include both chemical and non-chemical stress agents. Because chemical sources of degradation are addressed in other categories, this category includes physical modifications (such as mining and highway construction) and other sources of degradation (such as dumping of plastics and other litter) that affect terrestrial ecosystems/habitats.

Effects on undisturbed lands/habitats that result from nearby degradation (habitat fragmentation, migration path blockage) are also included in this problem area. EPA often has no regulatory authority over sources of physical degradation, while in other cases it may be able to influence them through the NEPA/EIS process.

23. Stratospheric Ozone Depletion

The stratospheric ozone layer shields the earth's surface from harmful ultraviolet (UV-B) radiation. Releases of chlorofluorocarbons (CFC's) and nitrogen dioxide from industrial processes and solid waste sites could significantly reduce the ozone layer. Although this is clearly a national and international problem, regional projects may wish to estimate their region's contribution to the problem, and analyze the effects of ozone depletion on their region.

24. $C0_2$ and Global Warming

Atmospheric concentrations of carbon dioxide (CO_2) are projected to increase over the next century due to an increase in fossil fuel combustion and a decrease in tropical rain forests and other $C0_2$ sinks. Higher levels of $C0_2$ may raise climatic temperatures globally, raising the sea level and disrupting weather patterns. As with Stratospheric Ozone Depletion, this is clearly a national and international problem, but regional projects may with to estimate their region's contribution to the problem and the likely effects of the problem on their regions.

ATTACHMENT B

GLOSSARY

Abiotic - Devoid of life, nonliving.

Acceptable Daily Intake - An estimate of the daily exposure dose that is likely to be without deleterious effect even if continued exposure occurs over a lifetime.

Acetylcholine - Chemical transmitter of nerve impulses at parasympathetic nerve endings (motor nerves to skeletal muscles).

Acetylcholinesterase (ACHE) - Enzyme which hydrolyses (chemically inactivates) acetylcholine. Organophosphate pesticides inhibit ACHE causing death by paralysis of skeletal muscle due to the over-activity of acetylcholine (cholinergic crisis).

ACHE - Acetylcholinesterase enzyme (hydrolyses acetylcholine)

Acute Exposure - A one-time or short-term exposure (usually high-level) that may or may not cause a health problem.

ADI - Acceptable Daily Intake

Ambient Air - Any unconfined portion of the atmosphere; open air.

Anecdotal data - Data based on descriptions of individual cases rather than on controlled studies.

Anoxia - Absence or lack of oxygen; reduction of oxygen in the body tissues below physiologic levels.

Area of Impact - An area subjected to a given environmental stressor measured in acres, hectares, sq. km., stream miles, counties, cities, metropolitan statistical areas (MSA), etc.

Areal - Any particular extent of space or surface as a geographical region.

Arrhythmia - Any variation from the normal rhythm of the heartbeat.

Arteriosclerosis - Hardening and thickening of the walls of the arteries.

Asphyxiant - Chemical which owes its toxicity to the simple displacement of oxygen (i.e., propane).

Ataxia - Failure of muscular coordination; irregularity of muscular action.

Benign - Not malignant, remaining localized.

Bioaccumulation - Increased concentrations of a chemical in an organism compared to the surrounding environment.

Bioassay - The determination of the potency (bioactivity) or concentration of a test substance by noting its effects in live animals or in isolated organ preparations, as compared with the effect of a standard preparation.

Bioavailability - The physiological availability of a given amount of a substance, as distinct from its chemical potency.

Biotic - Pertaining to life or living organisms, caused or produced by or comprising living organisms.

Bradycardia - Slowness of the heartbeat, as evidenced by slowing of pulse rate to less than 60.

Bronchoconstriction - Narrowing of the air passages of the lungs.

BW - Body weight

Carcinogen - An agent capable of inducing a cancer response.

Carcinogenic - Producing or inciting cancer.

Carcinogens, EPA Classification of, from Guidelines for Carcinogen Risk Assessment (51 FR 33992-34003, September 24, 1986) -

Group A: human carcinogen (sufficient evidence from epidemiologic studies);
Group B: probable human carcinogen (Subgroup Bl: limited evidence from epidemiologic studies; Subgroup B2: sufficient evidence from animal studies and inadequate evidence or no data from epidemiologic studies);
Group C: possible human carcinogen (limited evidence from animal studies and no data from epidemiologic studies);
Group D: Not classifiable as to human carcinogenicity (inadequate human and animal evidence of carcinogenicity or for which no data are available);
Group E: Evidence for non-carcinogenicity for humans (no evidence for carcinogenicity in animal and/or epidemiology test or studies).

CAS - Chemical Abstracts Service (chemical identification system)

Case Control Study - An epidemiological study that looks back in time at the exposure history of individuals who have the health effect (cases) and at a group who do not (controls),to ascertain whether they differ in proportion exposed to the chemical under investigation.

CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act

CFR - Code of Federal Regulations

Chloracne - Acne like eruption caused by exposure to chlorine compounds.

Cholinesterase - An enzyme which hydrolyses acetylcholine into choline and acetic acid and is important in the functioning of the nervous system.

Chronic effect - A biological change produced by an alteration in the environment and persisting over a major portion of lifetime.

Chronic exposure - Exposure (usually low-level) during a major portion of lifetime to an environmental alteration that may or may not cause a health problem.

Chronic Study - An experiment in which certain biological parameters are measured during and/or after exposure to an altered environment during a major portion of lifetime.

CNS - Central Nervous System (the brain and spinal cord)

Cohort Study - An epidemiological study that observes subjects in differently exposed group and compares the incidence of symptoms. Although ordinarily prospective in nature, such a study is sometimes carried out retrospectively, using historical data.

Conjunctivitis - Inflammation of the lining of the eyelids.

Control Group - A group of subjects observed in the absence of agent exposure or, in the instance of a case/control study, in the absence of an adverse response.

Critical Effect - The first adverse effect, or its known precursor, that occurs as the dose rate increases.

Cryogenic - Pertaining to or causing the production of low temperatures.

Cumulative Impact - The impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or Non-Federal) or person undertakes such other actions (NEPA, 1970).

CWA - Clean Water Act

Cyanosis - Bluish discoloration, especially of the skin and mucous membranes and fingernail beds.

Degree of Impact - The severity with which a stressor acts on an indicator on a relative scale.

Dermal - Pertaining to the skin.

Dermatitis - Inflammation of the skin.

Developmental toxicity - The study of adverse effects on the developing organism (including death, structural abnormality, altered growth, or functional deficiency) resulting from exposure prior to conception (in either parent), during prenatal development, or postnatally up to the time of sexual maturation.

Diversity - A measure of biotic stability, as measured by species richness and population numbers.

Dose-response relationship - A relationship between the amount of an agent (either administered, absorbed, or believed to be effective) and changes in certain aspects of the biological system (usually toxic effects), apparently in response to the agent.

DOT - U.S. Department of Transportation

Dysfunction - Abnormal, impaired, or incomplete functioning.

Dyspnea - Difficult or labored breathing.

Ecological Risk Assessment - Ecological risk assessment is a procedure for estimating the probability of and severity of adverse effects on species, biotic communities, and ecosystem structure and function.

Ecoregion - Large scale regions (15,000 - 33,000 sq. Km.) delineated on the basis of patterns of climate, soil, geology, vegetation, and physiography (Omernick, 1987).

Ecosystem - Includes the biotic community and the abiotic environment for a given area (Odum, 1975).

Edema - Presence of abnormally large amounts of fluid in intercellular spaces of body tissues.

End point - The final result of a series of changes or processes.

Environmental Impact - Some agent or action will cause an effect which will, at varying levels, cause harm to non-human populations.

EPA - U.S. Environmental Protection Agency

Epithelium - Cells covering the internal and external surfaces of the body.

Erythema - Redness of the skin produced by congestion of the capillaries.

Estimated exposure dose - The estimated or calculated dose to which humans are likely to be exposed.

Excess lifetime risk - The additional or extra risk incurred over the lifetime of an individual by exposure to a to)dc substance.

Exothermic - Denoting a chemical reaction characterized by the development or liberation of heat.

Extra Risk - The possibility that the agent produced an observed response, as distinguished from the probability that the response was caused by a spontaneous event unrelated to the agent.

Extrapolation - An estimation of the numerical value of an empirical function at a point outside the range of data that established the function.

Fetotoxic - Toxic to fetuses.

FIFRA - Federal Insecticide, Fungicide, and Rodenticide Act

Flash point - The lowest temperature at which the vapor of a volatile oil will ignite with a flash.

Fumigant - A pesticide that is vaporized to kill pests.

Fungicide - A substance that kills fungi or checks the growth of spores.

Gastrointestinal - Pertaining to the stomach and intestine.

Geographic Information System (GIS) - Computerized mapping system used to automate, manipulate, analyze and display geographic data in digital form. The major advantage of a GIS system is that it allows you to identify the spatial relationships between map features.

Guidelines for Carcinogen Risk Assessment - Agency guidelines intended to guide Agency evaluation of suspect carcinogens in line with the policies and procedures established in the statues administered by the EPA. See 51 FR 33992-34003, September 24, 1986.

Guidelines for Exposure Assessment - Agency guidelines intended to guide Agency analysis of exposure assessment data in line with the policies and procedures established in the statutes administered by the EPA. See 51 FR 34042-34054, September 24, 1986.

Guidelines for Health Assessment of Suspect Developmental Toxicants - Agency guidelines intended to guide Agency analysis of developmental toxicity data in line with the policy and procedures established in the statues administered by the EPA. See 51 FR 34014-34025, September 24, 1986.

Guidelines for the Health Risk Assessment of Chemical Mixtures -Agency guidelines intended to guide Agency analysis of information relating to health effects data on chemical mixtures in line with the policy and procedures established in the statutes administered by the EPA. See 51 FR 34014-34025, September 24, 1986.

HA - Health Advisory

Half-life - Ile time in which the concentration of a substance will be reduced by half.

Halogen - Any of the five nonmetallic chemical elements fluorine, chlorine, bromine, astatine, and iodine.

Halon - Halogenated hydrocarbon (e.g., carbon tetrachloride).

Health Advisory - An estimate of acceptable drinking water levels for a chemical substance based on health effects information. A health advisory is not a legally enforceable Federal standard, but serves as technical guidance to assist federal, state, and local officials.

Health Hazard -

Acute - Immediate to@c effects.
Chronic - Persistent or prolonged injury
Delayed - Toxic effect occurring after a lapse of time.

Hematuria - Blood in the urine.

Hepatic - Pertaining to the liver.

Herbicide - A substance that controls or destroys undesirable plants.

Homeostasis - Maintenance of normal, internal stability in an organism by coordinate responses of the organ systems that automatically compensate for environmental changes.

HSDB - Hazardous Substance Data Base

Human equivalent dose - The human dose of an agent which is believed to induce the same magnitude of toxic effect that the known animal dose has induced.

Hydrolysis - Double decomposition reaction involving the splitting of water into its ions and the formation of a weak acid and/or a weak base.

Hyperactivity - Abnormally increased activity.

Hyperpyrexia - A highly elevated body temperature.

Hypersalivation - Excessive secretion of saliva.

Hypertension - Persistently high arterial blood pressure.

Hypoxemia - Deficient oxygenation of the blood.

Hypoxia - Low oxygen content or tension; deficiency of oxygen in the inspired air.

IARC - International Agency for Research on Cancer

Inadequate evidence - According to the EPA carcinogen risk assessment guidelines, inadequate evidence is a collection of facts and accepted scientific inferences which is not definitive enough to allow conclusions to be drawn.

Incidence - The number of new cases of a disease within a specified period of time.

Individual Risk - The probability that an individual person will experience an adverse effect.

Initiation - The ability of an agent to induce a change in a tissue which leads to the induction of tumors after a second agent, called a promoter, is administered to the tissue repeatedly.

In vitro - Isolated from the living organism and artificially maintained, as in a test tube.

In vivo - Occurring within the living organism.

IRIS - Integrated Risk Information System

Jaundice - Syndrome characterized by hyperbilirubinemia and deposition of bile pigment in the skin, resulting in yellow appearance of the patient.

KG - Kilogram

L - Liter

Lachrymator - A substance which increases the flow of tears.

Lacrimation - Secretion and discharge of tears.

Laryngospasm - Spasmodic closure of the larynx.

Lyrnx - The muscular and cartilage structure situated at the top of the trachea (windpipe) and below the root of the tongue, functioning as sphincter into the trachea and as the organ of voice.

Lassitude - Weakness, exhaustion.

Latency - A state of seeming inactivity.

LC50 - Lethal Concentration 50, the concentration at which 50% of the animals died; a calculated value

LD50 - Lethal Dose 50; the dose at which 50% of the animals died; a calculated value

Lesion - A pathologic or traumatic discontinuity of tissue or loss of function of a part.

Lethal - Deadly; fatal.

Leukopenia - Reduction in the number of leukocytes in the blood.

Limited evidence - According to the EPA carcinogen risk assessment guidelines, limited evidence is a collection of facts and accepted scientific inferences which suggests that the agent may be causing an effect but the suggestion is not strong enough to be an established fact.

Linearized Multistage Procedure - A sequence of steps in which a) the multistage model is fitted to the tumor incidence data; b) the maximum linear term consistent with the data is calculated; c) the low-dose slope of the dose-response function is equated to the coefficient of the maximum linear term; and d) the resulting slope is then equated to the upper bound of potency.

LOAEL - Lowest Observed Adverse Effect Level

Lowest observed adverse effect level - The lowest dose in an experimental study at which a statistically or biologically significant adverse effect was observed.

Malaise - A vague feeling of bodily discomfort.

Malignant - Tending to become progressively worse and to result in death. Having the properties of anaplasia, invasion, and metastasis.

Mania - A phase of mental disorder characterized by an expansive emotional state, elation, over-talkativeness, and increased motor activity.

Margin of exposure - The ratio of the NOAEL and the EED, which, in the case of a regulatory decision, is the RfD, i.e., MOE = NOAEL/RfD.

Margin of safety - The term formerly applied to the Margin of Exposure concept.

Metastatic - Pertaining to the transfer of disease from one organ or part to another not directly connected with it.

Methemoglobinemia - Presence of methemoglobin (oxidized hemoglobin) in the blood.

MG - Milligram

Miosis (or myosis) - Contraction of the pupil.

Miscible - Capable of mixing in any ratio without separation of two phases, refers to liquid mixtures.

Modifying factor - An uncertainty factor, greater than zero and less than or equal to 10; its magnitude reflects professional judgment regarding aspects of the data used for the assessment; e.g., the completeness of the overall data base and the number of animals tested.

Mutagenic - Inducing genetic mutation.

Mydriasis - Extreme dilation of the pupil.

Myelosuppression - Suppression of the formation of bone marrow.

NAAQS - National Ambient Air Quality Standards

Narcotic - An agent that produces insensibility or stupor.

Necrosis - Death of tissue, usually as individual cells, as groups of cells, or in localized areas.

Nephritis - Inflammation of the kidney.

NESHAPS - National Emission Standards for Hazardous Air Pollutants

Neural - Pertaining to a nerve or to the nerves.

Neuropathy - Functional disturbances and/or pathological changes in the peripheral nervous system.

Neurotoxicity - Exerting a destructive or poisonous effect on nerve tissue.

NLM - National Library of Medicine

NOAEL - No Observed Adverse Effect Level

No data - According to the EPA carcinogen risk assessment guidelines, no data is a category of both human and animal evidence in which no studies are available from which to draw conclusions.

NOEL - No Observed Effect Level

No observed adverse effect level (NOAEL) - The highest experimental dose at which there was no statistically significant increase in a toxicologically significant end point.

No observed effect level (NOEL) - The highest experimental dose at which there was no statistically significant increase in any monitored end point.

NPDES - National Pollution Discharges Emission System

Ocular - Pertaining to or affecting the eye.

One-hit model - A dose response model of the form where P(d) refers to the $P(d) = I - \exp(- b d)$

Ophthalmic - Pertaining to the eye.

OSHA - U.S. Occupational Safety and Health Administration

Oxidizer - A substance that unites with oxygen, as in burning or rusting.

Palpitation - Unduly rapid heartbeat which is noted by the patient; it may be regular or irregular.

Parameter - A quantity which is constant under a given set of conditions, but may be different under other conditions.

Parasympathomimetic - Relating to drugs or chemicals having an action resembling that caused by stimulation of the parasympathetic nervous system; also called cholinomimetic.

Paresthesia - An abnormal sensation, as burning or prickling.

PEL - Permissible Exposure Limit

Perfusion - Liquid poured over or through an organ or tissue.

Pharmacokinetics - Movements of chemicals within biological systems, as affected by uptake, distribution, elimination, and biotransformation.

Photophobia - Abnormal visual intolerance of light.

Photosensitize - To induce a state of abnormal responsiveness to the influence of light.

Phytotoxic - Poisonous to plants; inhibiting plant growth.

Polydipsia - Excessive thirst persisting for long periods of time.

Polymerization - The process of joining two or more like molecules to form a more complex molecule.

Population risk - The number of cases occurring in a group of people.

Potency slope - Synonymous with slope factor.

POTW - Public Owned Treatment Works

PPB - Parts per billion

PPM - Parts per million

Proteinuria - An excess of serum proteins in the urine; also called albuminuria.

Psychosis - Any major mental disorder characterized by derangement of the personality and loss of contact with reality.

Pulmonary - Pertaining to the lungs.

RCRA - Resource Conservation and Recovery Act

RCRP - Regional Comparative Risk Project

Reactivity - Tendency of a substance to undergo chemical change.

Reference dose - An estimate (with uncertainty spanning perhaps an order of magnitude) of the daily exposure to the human population (including sensitive subgroups) that is likely to be without appreciable risk of deleterious effect during a lifetime. The RFD is expressed in units of mg/kg-b.w./day.

Registration (of a pesticide) - Under FIFRA and its amendments, new pesticide products cannot be sold unless they are registered with EPA. Registration involves a comprehensive evaluation of risks and benefits based on all relevant data.

Regulatory dose - The dose reflected in the final risk management decision.

Renal - Pertaining to the kidney.

Reportable quantity - The quantity of a hazardous substance that is considered reportable under CERCLA. Reportable quantities are: (1) one pound, or (2) for selected substances, an amount established by regulation either under CERCLA or under Section 311 of the Clean Water Act Quantities are measured over a 24 hour period.

Residual Risk - The risk that remains given current levels of control in place and current levels of non-compliance with regulatory requirements.

RfD - Reference Dose

Risk - The difference between the cancer incidence in the treated group of animals or the exposed humans and the control group of animals or the spontaneous incidence in humans.

Risk Assessment - The scientific activity of evaluation the toxic properties of a chemical and the conditions of human exposure to it in order both to ascertain the likelihood that exposed humans will be adversely affected, and to characterize the nature of the effects they may experience.

RQ - Reportable Quantity

RTECS - Registry of Toxic Effects of Chemical Substances

SAB - Science Advisory Board

Safety factor - The term formally applied to the uncertainty factor concept.

SDWA - Safe Drinking Water Act

Serum - The clear, watery fluid that moistens the surface of internal membranes; the watery portion of blood which remains after the blood clots.

Slope factor - The slope of the upper-bound dose extrapolation model at doses approaching zero.

SMR - Standardized Mortality Ratio

Specific gravity - The ratio of the density of a material to the density of some standard material; also known as relative density.

Standard Metropolitan Statistical Area (SMSA) - To be designated as a SMSA in 1980 an area had to have at least one city with a population of 50,000 or more or have a total urbanized population of 100,000 (75,000 in New England). The standards for SMSA designation specify that the counties which include the central city and adjacent counties, if they are at least 50% urbanized, be included in the SMSA- After 1980, the term "statistical" was dropped in SMSA, therefore the new term is SMA.

Standardized mortality ratio - The ratio of the number of deaths observed in the study group to the number of deaths "expected" in the study group under the set of rates for the control population.

STEL - Short-term exposure limit

Subchronic effect - A biological change resulting from an environmental alteration lasting about 10% of lifetime.

Subchronic exposure - An environmental alteration occurring over about 10% of lifetime.

Sufficient evidence - According to the EPA carcinogen risk assessment guidelines, sufficient evidence is a collection of facts and accepted scientific inferences which is definitive enough to establish that the observed effect is caused by the agent in question.
Superfund - Federal authority, established by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in 1980, to respond directly to releases or threatened releases of hazardous substances that may endanger health or welfare.

Systemic - Pertaining to or affecting the body or organism as a whole.

Systemic Effects - Systemic effects are those that require absorption and distribution of the toxicant to a site distant from its entry point at which point effects are produced. Most chemicals that produce systemic toxicity do not cause a similar degree of toxicity in all organs but usually demonstrate major toxicity to one or two organs. These are referred to as the target organs of toxicity for that chemical. Toxicology: The Basic Science of Poisons, Casarett and Doull, Second Edition, MacMillan Publishing Co., Inc., 1980. (Operationally EPA does not include carcinogens in this category).

Tachycardia - Excessively rapid heartbeat.

Target Organ of Toxicity - See Systemic Effects.

Teratogenic - Tending to produce anomalies of formation of development.

Threshold - A dose at which an effect occurs.

TLV - Threshold Limit Value

Toxic - Pertaining to, due to, or of the nature of a poison.

TSCA - Toxic Substances Control Act

Tumor progression - The sequence of changes in which a tumor develops from a microscopic lesion to a malignant stage.

TWA - Time-Weighted Average

ug - Microgram

Uncertainty Factor - Factor used in operationally deriving the RfD from experimental data. UFs are intended to account for (1) the variation in sensitivity among the members of the human population; (2) the uncertainty in extrapolating animal data to the case of humans; (3) the uncertainty in extrapolating from data obtained in a study that is of less-than-lifetime exposure; and (4) the uncertainty in using LOAEL data rather than NOAEL data. Usually each of these factors are set equal to 10.

Unit risk - The incremental upper-bound lifetime risk estimated to result from lifetime exposure to an agent if it is in the air at a concentration of 1 microgram per cubic meter or in the water at a concentration of I microgram per liter.

Upper Bound. Risk -

Urticaria - A vascular reaction of the skin marked by the transient appearance of smooth, slightly

elevated patches (wheals) which are redder or paler than the surrounding skin and often attended by severe itching.

Vasodilation - Dilation (expansion) of a blood vessel, leading to increased blood flow.

Ventricular fibrillation - Irregular heartbeat characterized by uncoordinated contractions of the ventricle.

Vertigo - Dizziness; an illusion of movement as if the external world were revolving around an individual or as if the individual were revolving in space.

VOC - Volatile Organic Compound

Volatile - Readily vaporized at a relatively low temperature.

Weight-of-evidence for carcinogenicity - 'ne end result of process in which all relevant factors affecting the likelihood that the agent is a human carcinogen are evaluated.

WQC - Water Quality Criteria

ATTACHMENT C

ECOLOGICAL RANKINGS
REGIONAL COMPARISON

REGION 6

PHYS. DEGRADATION (-TERRESTRIAL)
PESTICIDE APPLICATION

PHYS. DEGRADATION (WATER)
GLOBAL WARMING
STRAT. OZONE DEPLETION

NON-POINT SOURCE DISC.

HAZ/TOXIC AIR POLLUTANTS

OZONE/CARBON MONOXIDE
MUNI. WASTEWATER DISC.
RCRA SITES

IND. WASTEWATER DISC.
GROUNDWATER
MUNI. WASTE SITES
IND. WASTE SITES
ACCIDENTAL RELEASES

SUPERFUND SITES
PARTICULATE MATTER
AIRBORNE LEAD
STORAGE TANKS

REGION I

CRITERIA AIR POLLUTANTS
ACID DEPOSITION

IND. POINT SOURCE DISC.

POTW DISCHARGES
NON-POINT SOURCE DISC.
HABITAT LOSS

ACCIDENTAL RELEASES

SUPERFUND SITES
IND. WASTE SITES

MUNI. WASTE SITES
GROUNDWATER

PESTICIDES ON FOOD
PESTICIDE APPLICATION
RCRA SITES

STORAGE TANKS

RADON

INDOOR AIR POLLUTANTS
DRINKING WATER
LEAD
ASBESTOS
RADIATION OTHER THAN RADON

REGION 3

TERRESTRIAL HABITAT MODIFICATION
AQUATIC HABITAT MODIFICATION
NON-POINT SOURCE DISC.

ACID DEPOSITION
SUPERFUND SITES
CRITERIA AIR POLLUTANTS
AIR TOXICS

UNDERGROUND STORAGE TANKS
IND. POINT SOURCE DISC.
RADIATION OTHER THAN RADON
POTW DISCHARGES
RCRA SITES

SOLID WASTE SITES
RADON
INDOOR AIR POLLUTANTS
GROUNDWATER
PESTICIDES
WATER SUPPLY

REGION 10

NON-CHEM. DEGRADATION (TER)
NON-CHEM. DEGRADATION (WATER)
PESTICIDES

NON-POINT SOURCE DISC.

IND. POINT SOURCE DISC.

CRITERIA AIR POLLUTANTS
POTW DISCHARGES

ACCIDENTAL RELEASES

ACID DEPOSITION
HAZ/TOXIC AIR POLLUTANTS
RCRA SITES
SUPERFUND SITES

STORAGE TANKS
MUNI/IND. WASTE SITES
RADIATION OTHER THAN RADON

HUMAN HEALTH RANKINGS
REGIONAL COMPARISON

REGION 6	REGION 1	REGION 3	REGION 10
PESTICIDES	CRITERIA AIR POLLUTANTS	INDOOR AIR POLLUTANTS	INDOOR RADON
INDOOR RADON	RADON	INDOOR RADON	INDOOR AIR POLLUTION
INDOOR AIR POLLUTION	LEAD	PESTICIDES	PESTICIDES
OZONE / CARBON MONOXIDE		RADIATION OTHER THAN RADON	AIR TOXICS/PARTICULATES
STRAT. OZONE DEPLETION	ACID DEPOSITION	NON-POINT SOURCE DIS.	NON-PUBLIC DRINKING WATER
	INDOOR AIR POLLUTANTS	WATER SUPPLY	
DRINKING WATER	IND. POINT SOURCE DIS.	ACID DEPOSITION	PUBLIC DRINKING WATER
HAZ/TOX AIR POLLUTANTS	DRINKING WATER	POTW DISCHARGES	GROUNDWATER
	GROUNDWATER	CRITERIA AIR POLLUTANTS	
AIRBORNE LEAD	PESTICIDE RESIDUE/FOOD		CRITERIA AIR POLLUTANTS
RADIATION OTHER THAN RADON		GROUNDWATER	
	HAZ/TOXIC AIR POLLUTANTS	IND. POINT SOURCE DIS.	
		RCRA SITES	NON-POINT SOURCE DIS.
SUPERFUND SITES	ASBESTOS	SUPERFUND SITES	POTW DISCHARGES
RCRA SITES	DIS. TO ESTUARIES/OCEAN	AIR TOXICS	ACCIDENTAL RELEASES
MUNICIPAL WASTEWATER DISCHARGES	NON-POINT SOURCE DIS.	SOLID WASTE	SUPERFUND SITES
		HABITAT MODIFICATION (TER.)	
INDUSTRIAL WASTEWATER DISCHARGES	POTW DISCHARGES		RADIATION OTHER THAN RADON
	ACCIDENTAL RELEASES	UNDERGROUND STORAGE TANKS	STORAGE TANKS
SO/NO	STORAGE TANKS		IND. POINT SOURCES
STORAGE TANKS	PESTICIDE APPLICATION	HABITAT MODIFICATION (WATER)	RCRA SITES
PARTICULATE MATTER			IND/MUN WASTE SITES
ACCIDENTAL RELEASES	RADIATION OTHER THAN RADON		
GROUNDWATER			
	RCRA SITES		
NON-POINT SOURCE DISCHARGES	SUPERFUND SITES		
	MUN. WASTESITES		
MUN. SOLID WASTE SITES	IND. WASTESITES		
IND. SOLID WASTE SITES			

ECONOMIC RANKING

REGIONAL COMPARISON

REGION 6

GLOBAL WARMING
STRAT. OZONE DEPLETION
OZONE/CARBON MONOXIDE

INDOOR RADON
INDOOR AIR POLLUTANTS
PHYS. DEGRADATION, WATER WETLANDS
NON-POINT SOURCE DISCHARGES
PARTICULATE MATTER
S02/NO

IND. WASTEWATER DISCHARGES
MUNICIPAL WASTEWATER DISCHARGES
HAZ/TOXIC AIR POLLUTANTS
DRINKING WATER
GROUND WATER
PESTICIDES
OIL PRODUCTION/STORAGE/TRANSPORTATION

STORAGE TANKS
RCRA SITES
SUPERFUND SITES
MUN. SOLID WASTE SITES ND. SOLID WASTE SITES
ACCIDENTAL RELEASES
RADIATION OTHER THAN RADON

REGION 3

CRITERIA AIR POLLUT
ACID DEPOSITION
NON-POINT SOURCE DISCHARGES
WATER SUPPLY
INDOOR AIR POLLUTANTS
INDOOR RADON
PESTICIDES
POTW DISCHARGES
RADIATION OTHER THAN RADON
UNDERGROUND STORAGE TANKS
IND. POINT SOURCE DISCHARGES GROUND WATER
RCRA SITES
TERRESTRIAL HABITAT MODIFICATION
IND./MUNI. SOLID WASTE SITES
AQUATIC HABITAT MODIFICATION
SUPERFUND SITES
HAZ/TOXIC AIR POLLUT

ATTACHMENT E

SUMMARY: PROGRAM REPORT'S

INDUSTRIAL DISCHARGE TO SURFACE WATER
Combined Risk Category Ranking: 3

Problem Area No. 1

Bioaccumulation of toxic chemicals in fish

Substances Reviewed

2,3,7,8 Tetrachlorodibenzo-p-dioxin (Dioxin)
Hexachlorobenzene
Mercury

Comments

Cancer Risk: Only two chemicals were reviewed (dioxin and hexachlorobenzene). The estimated numbers of annual cancer were 11. These were due almost entirely to dioxin.

Non-cancer Risk: Only one chemical was reviewed (mercury). No exceedances of the reference dose (RfD) were calculated.

Data used to calculate risks were as follows:
1) fish tissue data from the National Bioaccumulation Study;

2) toxic potencies obtained from water quality criteria documents (dioxin and hexachlorobenzene) and IRIS (mercury);

3) county population figures taken from the Bureau of Census population estimates for July, 1988.

Uncertainty

High Only three chemicals were evaluated. Additionally there is limited data for toxic chemicals in fish tissue.

Assumptions

An average fish consumption rate of 6.5 grams per day was used to estimate exposures. Exposed populations were those in counties or parishes surrounding significant metropolitan areas.

MUNICIPAL DISCHARGE TO SURFACE WATER
Combined Risk Category Ranking 3

Problem area No. 2

Contamination of potable source surface waters and bioaccumulation of toxic chemicals in fish

Substances Reviewed

Chlorobenzenes (1,2,4,5 Tetrachlorobenzene, 1,2,3,5 Tetrachlorobenzene, Trichlorobenzene, Pentachlorobenzene)
Methylene Chloride
Tetrachloroethylene
Arsenic
Mercury
Chromium
Selenium
Nickel
Cadmium
Fecal Bacteria

Comments

Cancer Risk: Fish tissue and water data existed to adequately address four carcinogens commonly detected in municipal effluents in Region 6: the chlorobenzene consortium, methylene chloride, tetrachloroethylene and arsenic. The estimated numbers of annual cancers was 19, with arsenic being the largest contributor to the total cases.

Non-cancer Risk: Fish tissue, ambient water and discharge concentration data existed to adequately address non-cancer effects from six toxins: mercury, chromium, selenium, nickel, cadmium and fecal bacteria. Of the toxic metals, only mercury had exposure values which exceeded the Reference Dose (RfD). Exceedances were at three sites in the Region, Dallas/Ft. Worth, Texas, and Lake Charles and Baton Rouge, Louisiana In a qualitative risk ranking which accounts for severity of the health effect (teratogenicity), the population exposed, and the exposure dose, the risk score for mercury in Region 6 is 9 of a possible 12.

Risk from fecal contamination was assessed for two well-characterized sites in the Region, The Tangipahoa River in Louisiana and the Middle Arkansas River in Oklahoma. The levels of fecal indicator bacteria predicted an increase of 72 cases of gastroenteritis in the former and 130 cases in the latter location.

Data used to calculate risks were as follows:

1) fish tissue data from the National Bioaccumulation Study, the Arkansas Water Quality Inventory Report 1990, Results of Intensive Priority Pollutant Monitoring in Texas-Phase II, 1989, and an Intensive Survey of the San Antonio River Segment 1901 (1984).

2) ambient water data from STORET, USGS Water Quality Surveys for states of Texas, Arkansas, and Oklahoma and Louisiana, State of Louisiana Water Quality Management Plan-Water Quality Data Summary 1987. Where ambient data was available, tissue data was estimated using bioconcentration factors.

3) ambient water data was also predicted from effluent concentrations where this data was available

4) toxic potencies and reference doses were obtained from water quality criteria documents and IRIS

5) county population figures were taken from the Bureau of Census population estimates for July 1988.

Uncertainty

High The chemicals evaluated were restricted by available fish and water quality data and do not represent the entire set of chemicals posing a bioaccumulative challenge in the Region. The risk from fecal penetration to the environment from municipal discharges was constrained by the inability of the bacterial indicators to distinguish animal from human waste.

Assumptions

An average fish consumption rate of 6.5 grams per day was used to estimate exposures in inland locales, 20.0 grams per day in coastal areas. For locales in which the proximal waterbodies were used as a source of domestic water, the additional exposure of 2 liters/day ingestion was included in the analyses. Exposed populations were those in counties of parishes surrounding significant metropolitan areas.

AGGREGATE DRINKING WATER
Combined Risk Category Ranking: 2

Problem Area No. 3

Drinking Water (Public and Private)

Substances Reviewed

Total Trihalomethanes (TTHM's)
Nitrate
cis-1,2 Dichloroetyhylene
Dichlorodifluoromethane
Tetrachloroethylene
Trichloroethylene
Microbiology
Turbidity
Combined Radium
Radon
Volatile Organic Compounds (VOC's)
Fluoride
Benzene
Ethylbenzene
Toluene
Xylene(s)
Lead
Arsenic
Barium
Selenium
Coliform

Comments

Cancer Risk: Estimated annual cancer incidence for TTHM, combined radium, VOC's and radon is 199 in Region 6. A large portion of this estimate (196) is attributable to radon exposure in public water supplies.

Non-Cancer Risk: Approximately 4.6 million Region 6 residents may be exposed to unsafe levels of the 10 non-carcinogens reviewed. Four million two-hundred thousand Region 6 residents may be exposed to drinking water with greater than 20 ug/l of lead. Approximately 2.7 million residents could be exposed to microbiological contamination (MCL and/or monitoring violations).

Public water systems supply drinking water to 88% of the Region 6 population. The remaining 12% is served by domestic (individual or farm type) systems that are not under governmental jurisdiction. For this population there are no water quality data available and they have not been included in this assessment. Two exceptions are lead and radon for which the evaluations are based on portions of the total Regional and national exposure respectively. In Region 6 MCL's have been exceeded for arsenic fluoride, nitrate, radium 226 and 228, selenium, total halomethane and trichloroethylene.

It is estimated that 204 municipal wells were contaminated and replaced last year (1989) and 100 to 300 private wells. Contamination from pesticides is estimated to have occurred in 98 wells (no data for Oklahoma).

The entire Region 6 population is potentially exposed to drinking water contaminations (approximately 28.5 million). There are very few data on actual illness caused by water toxins. **A** major challenge of water utility operations is to sustain reliable disinfection while minimizing the possibility of forming by-products of disinfection that may be harmful.

Uncertainty

Moderate	Good animal and epidemiology data for selected chemicals, limited population exposure data, possible double counting for contaminated drinking water wells, suspected under-reporting of disease incidence

Assumptions

1. The number of persons exposed to lead levels exceeding 20 ugA was estimated for Region 6 by assuming 10 percent of the national estimate of 42 million people.

2. Health impacts of the non-carcinogenic compounds are considered only when contaminant levels exceed the MCL or Health Advisory Level.

3. For this assessment it is assumed that 10 percent of the estimated total radon cancer incidents in Region 6 are attributed to drinking water, and that 77 percent (196 cases) are attributed to public water supplies. The remaining are listed under Aggregate Ground Water.

4. The adverse health impacts of non-carcinogens was assumed to be a function of the concentration divided by the D@L (Drinking Water Equivalent Level).

5. For this assessment it is assumed that 10% of the estimated national exposure to lead in drinking water occur in Region 6.

6. Contaminant concentrations are monitored at varying frequencies. Concentrations are assumed to be constant during time between measurements.

7. Health effects assumptions are those documented in various EPA documents (IRIS, Health Advisories and Guidelines for Carcinogenic Risk Assessment).

NON-POINT SOURCE DISCHARGES TO OCEANS, LAKES, AND
Combined Risk Category Ranking: 3

Problem Area No. 4

Non-Point Source Discharges to Ocean, Lakes, Rivers

Substances Reviewed

Chlordane
Dieldrin
PCBS
Endrin

Comments

Cancer Risk: For the three chemicals assessed for cancer risks -chlordane, dieldrin, and PCBs - a risk of 70 additional cancer cases was estimated. This number was due mainly to PCBS with an estimate of 59 additional cancer cases.

Non-Cancer Risk: Only one chemical was reviewed (endrin) for Louisiana. The risk was determined insignificant. The other states were assumed to show the same result (exposure dose less than the reference dose).

Data used to calculate risks were: 1) fish tissue data from the National Bioaccumulation Study; 2) toxic potencies obtained from IRIS; 3) county population figures taken from the Bureau of Census population estimates for July, 1988.

Uncertainty

High Only four chemicals were evaluated. There is limited data for toxic chemicals in fish tissue from non-point sources. Contaminated sediments cannot be evaluated at this time.

Assumptions

An average fish consumption rate of 6.5 grams per day was used for non-coastal states and 20 grams per day was used for coastal states. The exposed populations were those in counties or parishes surrounding significant metropolitan areas or in rural areas in the county or parish where a waterbody was located.

AGGREGATE GROUND WATER CONTAMINATION
Combined Risk Category Ranking: 3

Problem Area No. 6

Aggregate Ground Water Contamination

Substances Reviewed

Nitrate	Fluoride
cis-1,2 Dichloroethane	Benzene
Tetrachloroethylene	Ethylbenzene
Trichloroethylene	Toluene
Microbiology	Xylene(s)
Combined Radium	Arsenic
Radon	Barium
Volatile Organic Compounds (VOC's)	Selenium

Comments

Included under "aggregate ground water" were the problem areas formerly identified under "Other Ground Water", as well as ground water concerns associated with the line programs.

Cancer Risk: Radon was estimated to be the largest source of cancer incidents originating from ground water sources in the Region. Radon exposure from domestic wells was estimated to account for 60 cancer cases annually. Other carcinogens in drinking water from ground water were estimated to result in one additional case.

Non-Cancer Risk: Based on figures collected under the Public Water Supply program, it was estimated that 439,100 people may be exposed through public water supply systems to unsafe levels of non-carcinogens from ground water. Exposure to ground water with microbial contamination can occur in public water supply systems but is difficult to quantify because contaminants can enter at various points in the distribution system as wen as through contaminated ground water.

The 3,400,000 persons who depend on unregulated private domestic wells in the region are probably exposed to much greater levels of contaminants in their drinking water than are PWS customers. A survey of nitrate contamination in Arkansas revealed that 3.2% of the rural wells sampled in 10 counties showed nitrate in excess of the MCL, suggesting that 109,000 rural residents in Region 6 may be exposed to nitrate levels exceeding the MCL In addition, an undetermined, but possibly even larger number of people may be exposed to microbiological contamination from private wells.

This type of contamination is most common in improperly constructed shallow wells.

The most direct available measure of health risks associated with ground water contamination is through the Public Water Supply program. Eighty-eight percent of the total Regional population is served by public water supply systems, while 12% depend on individual sources (almost entirely consisting of private wells.) In total, approximately half of the population of EPA Region 6 is dependent on ground water as a drinking water source, resulting in about 14.25 million people who are potentially exposed to ground water pollution. Of these, about 11 million are served by public water systems. It is probable that exposure rates exceeding health standards are higher for people served by private wells. In Texas alone, 2,244 incidents of ground water pollution were reported last year. In a 1988 Texas survey of domestic wells for pesticide residues, under circumstances of suspected ground water vulnerability, 10 wells were found to contain pesticides. Nitrates, in concentrations greater than the MCL, were detected in 101 wells. Eighty eight of these were used for household purposes. Twenty-eight of the wells used for household purposes contained arsenic at concentrations greater than the MCL These incidents point toward a major future impact on domestic water supply wells. There are also instances of large public water supply wells being contaminated, although more rare, such as a large capacity well in Albuquerque, New Mexico.

It is estimated that 204 municipal wells were contaminated and replaced last year (1989) and 100 to 300 private wells. Ninety-eight wells are estimated to have been contaminated by pesticides (no data for Oklahoma).

Potential sources of ground water contamination are widely scattered throughout the region and are extremely numerous, occurring in every geographic and cultural setting and associated with a vast array of human activities. They include the highly visible RCRA and CERCLA (Superfund) sites, the ubiquitous corner gasoline stations with their storage tanks, the farm fields sprayed with pesticides and fertilizers, the extensive oil and gas operations with their associated hydrocarbon and salt water contamination, the animal feedlots, the landfills, the septic tanks, the injection wells, the highway deicing operations and even graveyards. In addition, contaminated surface water can become contaminated ground water where abandoned water wells and oil wells have not been properly plugged and allow drainage from the surface. In some cases, such as contamination of private wells from septic systems, we are presented with situations where there is no federal control and there may be little state control on both the source of contamination and the well that supplies the drinking water.

Uncertainty

Moderate	good animal and epidemiology data for selected chemicals, limited population exposure data (especially for private well users), possible double counting for contaminated drinking water wells, suspected under-reporting of disease incidence.

Assumptions

1. Health impacts of the non-carcinogenic compounds are considered only when contaminant levels exceed the MCL or Health Advisory Level.

2. It is assumed that 10 percent of the radon cancer incidents in Region 6 are attributed to drinking water and two of these, 23 percent, or 60 cases are attributed to domestic ground water wells.

3. The adverse health impacts of non-carcinogens was assumed to be a function of the concentration divided by the DWEL (Drinking Water Equivalent Level).

UNDERGROUND STORAGE TANKS
Combined Risk Category Ranking: 3

Problem Area No. 7

Storage Tanks

Substances Reviewed

Primary constituents of gasoline and petroleum products

Aromatics	Paraffins	Olefins
Benzene	Butane	Butene
Ethylbenzene	Heptane	Isobutylene
Toluene	Isobutane	2-methyl-2-butene
Xylene	Isopentane	2-methyl-l-pentene
Napthalene	Methylpentane	5-pentene
	Pentane	1,3-butadiene
	Decane	2-butene
	Methylcyclopentane	Cyclohexene
	2,2,4-trimethylheptane	Cyclopentene
	2,2,5-trimethylhexane	Isobutene
		1,4-pentadiene
		2-pentene
		Propylene
		1-methyl-3-n-propylene

Comments

Cancer Risk: The R6 data indicates a moderate-low risk (RANKING - 3) based on the number of underground storage tanks, the number of leaking underground storage tanks, the total population, the number of people exposed, and the percent exposure. Included in the ranking is consideration of the known carcinogenic characteristics of the benzene and 1,3-butadiene and the generally unknown concentrations of these constituents. The odor threshold for benzene in air is 5 - 12 ppm and in water is 2 ppm. The taste threshold for benzene in water is 0.6 ppm. An EPA 10-day health advisory is issued at 1.6 ppm. One study of concentration of benzene in drinking water from a leaking underground storage tank reported test results of 7 ppm.

Non-cancer risk: The non-cancer risk is estimated to be less than the cancer risk because of the small percent of population affected (less than 1%).

The underground storage tank program has two elements. The underground storage tank regulations are meant to prevent tanks from leaking petroleum, petroleum products or hazardous substances into drinking water, ground water, and soil.

Therefore, every tank in the vicinity of drinking water is a potential health risk. The leaking underground storage program is designed to clean up known leaking tanks with priority to leaking tanks affecting drinking water.

For this risk assessment the total population exposed is 192,600 of a R6 total population of 28,661,500, or 0.67 percent of the population. The estimated number of water wells contaminated is 64,200 from 21,400 leaking underground storage tanks. The 21,400 leaking underground storage tanks are 10% of the R6 population of 214,000 underground storage tanks. In FY91-92, the Region will more accurately evaluate the number of underground storage tanks in the vicinity of drinking water wells in order to better characterize the risk and assess the pollution prevention opportunities for underground storage tanks.

Although batches of petroleum products differ, the main constituents recur. The chemical and physical properties of the constituents determine the pathways by which they will be transported. The constituents tend to separate into four pathways after a release from a storage tank: vapors, dissolved in water, adsorbed in soil, and floating on water. Therefore, the constituents are released into air, soil residuals, groundwater, and eventually some win reach surface water.

Health exposures will result from persons coming into contact with contaminated soil or water. Persons may inhale vapors that have entered a nearby building, ingest contaminants in contaminated drinking water or inhale volatile components released from contaminated water during showering.

Uncertainty

High Accurate data is difficult to collect for the large number of leaking tanks, the number of drinking water wells affected by a leak, and the number of people affected by **a** drinking water well.

Assumptions

1. The number of leaking underground storage tanks is 10% of the total number of tanks in Region 6.

2. A leaking tank pollutes 3 drinking water wells.

3. Three people are exposed for each drinking water well contaminated. (Maine study).

4. 1% of the population exposed constitutes less than moderate risk.

5. Unknown concentrations of carcinogenic constituents limit the risk to moderate levels.

RCRA HAZARDOUS WASTE
Combined Risk Category Ranking: 3

Problem Area No. 8

Active Hazardous Waste

Substances Reviewed

Polychlorinated biphenyls	Chromium
Trichloroethylene	Cadmium
Benzene	Chlorobenzene
Polynuclear aromatic hydrocarbons	Arsenic
Dichloroethane	Chlorinated Solvents

Comments

Cancer Risks: Approximately 700,000 people live within a 1 - mile radius of the RCRA facilities in Region 6. This is the population considered to be "at risk". Data from 40 of these facilities where releases have occurred indicates that the types of contaminants released are analogous to the types of contaminants released from Superfund sites. From this analogy, the Region assumed that the magnitude of risks posed by RCRA facilities would be similar to the risks posed by Superfund sites. The individual risk from RCRA facilities was estimated to be 3 x 10-' excess cancer incidents. Applying this individual risk to the population "at risk" yields an estimated 2,100 excess lifetime incidents or 30 incidents per year.

Non-cancer risks: The chronic non-cancer risks from RCRA facilities is assumed to be insignificant.

Uncertainty

Moderate	Uncertainty is associated with the lack of concentration data available for the documented releases. It is also associated with the extrapolation of data from 40 sites to an estimated 400 facilities in Region 6.

Assumptions:

1. The data from the 40 facilities evaluated is representative of all the facilities in the Region.
2. 700,000 people live within 1 mile of the RCRA sites in Region 6.
3. The wastes at and releases from RCRA facilities are similar to the wastes and releases at Superfund sites.
4. The risks associated with the releases from RCRA sites are comparable to the risks associated with Superfund sites.

CERCLA / ABANDONED SUPERFUND SITES
Combined Risk Category Ranking: 3

Problem Area No. 9

Abandoned Hazardous Waste Sites

Substances Reviewed

Polychlorinated biphenyls	Polynuclear Aromatic Hydrocarbons
Hexachlorobutadiene	2,3,7,8 - tetrachlorodibenzo-p-dioxin
Chromium	Cadmium
Arsenic	Benzene
Pentachlorophenol	Trichloroethylene

Comments

Cancer Risks: The estimate of the cancer risks from Superfund sites in Region 6 was based on the 22 baseline risk assessments reviewed for the problem area. The baseline risks posed at these 22 sites ranged from a 10-1 to 10-' excess lifetime cancer risk; the workgroup estimate the average baseline risk at 3 x 10-'.

From these baseline risk assessments, an average "at risk" population was estimated. Populations within a one - mile radius of these 22 sites ranged from 71,000 people to 500 people, with an average of 5,000 people. The workgroup thus assumed that 5,000 people are "at risk" at each current and potential Superfund site in Region 6.

The average baseline risk, 3 x 10-', and average population, 5,000 people, were then extrapolated to include all 74 current Superfund sites in Region 6. The workgroup also estimated that about 240 sites may be addressed by Superfund, based on 6% of 4,000 CERCLA sites in the Region, being included on the National Priorities List.

Based on this information, the workgroup estimated that 3,950 excess cancer incidents over 70 years, or 55 incidents per year may be due to exposure to unremediated Superfund sites in Region 6.

Non Cancer Risks: Based on 22 site risk assessments that were reviewed, non-cancer risks were assumed not to be significant (Hazard Index less than 1.0).

Uncertainty

Moderate: There is good data in the literature regarding the toxicity and epidemiology of the contaminants evaluated. The major cause of uncertainty is the extrapolation of risk and population from the 22 risk assessments reviewed to the total number of sites to be addressed in Superfund.

Assumptions

1. There are 4,000 potential sites in Region 6; six percent of these sites will make the National Priorities List.

2. An average of 5,000 people live within one mile of each Superfund site and are at risk from the sites.

3. Each site, if unaddressed, poses a 3 x 10-' excess lifetime cancer risk.

MUNICIPAL SOLID WASTE SITES
Combined Risk Category Ranking: 4

Problem Area No. 10

Municipal Solid Waste Sites

Substances Reviewed

Vinyl Chloride
Dichloromethane
1, 1,2,2-Tetrachloroethane
Arsenic
Carbon Tetrachloride

Comments

Cancer Risks: The workgroup estimated that less than 1 excess cancer incident is expected nationally from municipal solid waste sites.

Non Cancer Risks: Non cancer risks were assumed to be negligible.

Uncertainty

High The uncertainty is based on the lack of Regional data available; some uncertainty is introduced in the extrapolation of national data to a Regional level.

Assumptions

1. Based on national survey data 46% of facilities have drinking water wells within a one mile radius.

2. Contaminant migration via groundwater is based on a 300 - year modeling period.

3. Risk estimates are based on national data presented in the.40 CFR Parts 257 and 258 (Federal Register, August 30, 1988, page 33315 and following).

INDUSTRIAL SOLID WASTE
Combined Risk Category Ranking: 4

Problem Area No. 11

Industrial Solid Waste Sites

Substances Reviewed

Vinyl Chloride
Dichloromethane
1,1,2,2-Tetrachloroethane
Arsenic
Carbon Tetrachloride

Comments

The workgroup considered the cancer and non-cancer risks from Industrial Solid Waste Sites to be similar to the risks from Municipal Solid Waste Sites. This approach was taken because virtually no data was available, either in the Region or from the States, regarding releases from facilities and populations potentially impacted by any releases.

Uncertainty

High The lack of data available made any estimate of risk difficult. The approach taken by the workgroup for this problem area is similar to the approach taken by Region 1.

Assumptions

1. Based on national survey data 46% of facilities have drinking water wells within a one mile radius.

2. Contaminant migration via groundwater is based on a 300 - year modeling period.

3. Risk estimates are based on national data presented in the 40 CFR Parts 257 and 258 (Federal Register, August 30, 1988, page 33315 and following).

ACCIDENTAL CHEMICAL RELEASES
Combined Risk Category Ranking: 3

Problem Area No. 12

Accidental Chemical Releases

Substances Reviewed

Hazardous materials under CERCLA and SARA.

Comments

Cancer Risk: Incidents indeterminate. Virtually no data on exposure or concentrations. Non-cancer Risk: In Region 6 in FY89, there were 43 deaths and 271 injuries reported as directly resulting from releases of hazardous materials, almost all explosive materials. There has been no attempt to relate chronic disease to accidental releases.

Spills reported directly to the Region, and those relayed to the Region by the National Response Center, are entered into a computerized data base developed for tracking purposes. Tracking is by three separate categories, hazardous materials, oil and others. By category, hazardous materials includes spills reportable under CERCLA and SARA, oil related includes spills reportable under the Clean Water Act and other includes unknown spills, abandoned drums, fish kills.. The number of reported injuries has increased in succeeding years. Region 6 has approximately one-fifth of the spills reported nationwide. In FY89, 1585 releases of hazardous materials, involving more than 50 million pounds, were reported in Region 6. Most of these (81 percent) occurred in the high density manufacturing areas of the Baton Rouge/New Orleans corridor in Louisiana and the Gulf Coast area in Texas.

Uncertainty

Moderate Exposure and concentration data are non-existent. Injury data are probably under-reported.

Assumptions

1. There are no health risks due to chronic exposure.

2. Spills and accidents are under-reported.

PESTICIDES APPLICATION
Combined Risk Category Ranking: 1

Problem Area No. 13

Pesticides

Substances Reviewed

Alachlor	Chloropyrifos	EBDC's
Atrazine	2,4-D	Malathion
Benomyl	Diazinon	Methyl Parathion
Captan	Dicamba	Permethrin
Chlorothalonil	Dicofol	Propoxur
		Simazine
		Trifluralin

Comments

Cancer Risk: Non-Dietary or risk to farm workers, applicators, commercial and residential populations were judged to be moderate to high. The additive upper bound estimate for the listed chemicals ranged from 3 to 2,155 annual cancer cases for different sub-populations for a total of 2,481 annual cancer cases. Additive annual cancer cases resulting from Dietary exposure was estimated to be 390.

Non-Cancer Risk: Non-Diem risk to farm workers, applicators, and residents of single unit housing was judged to be high in Region 6. The hazard index calculations for the chemicals reviewed often exceeded "1" (range = 0.25 - 32,000) indicating exposures exceeding the RfD's.

Region 6 has a significant farm labor force. The Region's particular characteristics contributing to risk include many crops requiring hand-labor practices, the potential for unsafe work practices (child labor, pregnant women) and a language barrier. The workgroup believed that significant under reporting of pesticide poisoning exists in the Region and realizes that most of the pesticides in general use have not been adequately characterized as to their toxicological potential.

Uncertainty

Moderate	Effects of organophosphates and carbamate insecticides are well know, at risk populations identified, documented case studies, direct exposure common in farm workers and applicators, some human studies in volunteers.

Assumptions

1. People in Region 6 are exposed to the listed chemicals.

2. Toxicological assumptions are those generally accepted by EPA risk assessment scientists (i.e., estimated exposures, upper bound risk estimates, reliance upon animal toxicology data, etc.).

SULFUR DIOXIDE AND NITROGEN OXIDES
Combined Risk Category Ranking: 3

Problem Area No. 14

Sulfur Dioxide (SO_2)
Nitrogen Oxides (NO_x)

Substances Reviewed

SO_2 and NO_x

Comments

Cancer Risk: Assumed to be negligible

Non-Cancer Risk: The total population living in areas of Region 6 that exceed the SO standard is 4,049,738. This population includes the Houston, TX, MSA, Beaumont, TX, MSA, and Ponca City, OK- Health effects of exposure to SO, and NO,, include asthma, chronic bronchitis, and emphysema. Residents of areas which exceed the SO, standard are considered "at risk" populations. Approximately 10 % of this population may be asthma, bronchitis, or emphysema patients. As many as 400,000 people could be affected to some degree by the SO, exceedances.

Uncertainty

Moderate Respiratory effects of SO, and NO. are well known, at risk populations identified, ambient monitoring data available.

Assumptions

1. Exposure to SO, and NO,, does not contribute to the incidence of cancer in Region 6.

2. Subpopulations in areas that exceed the SO, standard are exposed to concentrations of S02 which put them at risk of experiencing adverse health effects.

OZONE / CARBON MONOXIDE
Combined Risk Category Ranking: 1

Problem Area No. 15

Ozone / Carbon Monoxide (CO)

Substances Reviewed

Ozone Carbon Monoxide

Comments

Cancer Risk: Assumed to be negligible.

Non-cancer Risk: The number of metropolitan area residents that live in non-attainment areas for ozone or carbon monoxide is estimated to be 11,126,499. Certain exposed subgroups can be identified as "at risk" from adverse health effects (populations at a higher probability of developing a condition or illness). The subgroups have been identified through clinical, field, and epidemiological studies, and include persons with pre-existing respiratory disease, elderly persons and pre-adolescent children for ozone and pregnant women and persons with preexisting heart disease for carbon monoxide.

Of the 11,126,499 people that live in the metropolitan areas that exceed the Ozone/CO NAAQS the "at risk" populations are:

Ozone	356,812	asthma
	423,750	chronic bronchitis and emphysema
Carbon Monoxide	101,851	pregnant women
	108,176	coronary heart disease
Total	1,283,291	

The calculated total number of restricted days, days that a person can not perform regular activities due to respiratory or cardiac affects of high ozone concentrations, is 292,704.

Uncertainty

Low Good animal, epidemiology, and population data; at risk populations well defined

Assumptions

1. Exposures to ozone and carbon monoxide do not contribute to the incidence of cancer in Region 6.

2. Subpopulations in non-attainment areas are exposed to unsafe atmospheric concentrations of ozone and carbon monoxide.

3. Ozone monitoring data from a few sites is representative of ozone concentrations over large metropolitan areas.

AIRBORNE LEAD
Combined Risk Category Ranking: 2

Problem Area No. 16

Airborne Lead

Substances Reviewed

Lead (Pb)

Comments

Cancer Risk: Lead is classified as a B, (probable) human carcinogen. Cancer incidence was not calculated because a cancer potency factor has not been established.

Non-cancer Risk: Two population groups were considered for non-cancer effects. There are 19,878 people living within 2 km from lead smelters in Region 6. Based on monitored data, 66 children of that population would be expected to exceed 10 ug/dl blood Pb levels within the receptor population of the site. Children with blood Pb levels between 10 - 15 ug/dl have been shown to experience impaired neurobehavioral function and development.

The second exposed population group analyzed was the residents of urbanized ozone non attainment areas greater than 200,000 population (Ozone non attainment used as criterion due to increased probability of traffic congestion which leads to an increased exposure to lead from automobile/truck exhaust). Of the 9,012,000 people in urban areas 18,248 were projected to be at risk to experience hypertension and central nervous system effects and 13,185 to experience peripheral nervous system effects and elevated blood lead levels.

In addition, the population of children located in Region 6 metropolitan areas exposed to lead paint that have blood lead levels exceeding 10 ug/dl is projected to be 682,357. This exposure is primarily through the oral pathway. The information is presented because it is a significant Region 6 population exposed that is not presented in another problem area.

Uncertainty

Moderate	Good animal and epidemiology data, available exposure data to include biological monitoring for smelter exposures only, extrapolations to urban areas raise the uncertainty.

Assumptions

1. Exposure to airborne lead does not contribute to the incidence of cancer in Region 6.

2. Subpopulations in urbanized areas may be exposed to unsafe concentrations of airborne lead.

PARTICULATE MATTER (PM_{10})
Combined Risk Category Ranking: 3

Problem Area No. 17

Particulate Matter (**PM_{10}**)

Substances Reviewed

Particulate Matter

Comments

Cancer Risk: Estimated annual deaths from particulate exposure total six in Region 6.

Non-cancer Risk: In Region 6, 1,082,746 people live in cities that violate the PM,,, standard. Certain exposed subgroups can be identified as "at risk" from adverse health effects (populations at a higher probability of developing a condition or illness). These subgroups are pre-adolescent children, elderly persons, and persons with pre-existing respiratory disease. The population at risk to asthma is 21,173 and risk for coronary heart disease is 49,056. The number of restricted days, days that a person can not perform normal activities due to particulate matter pollution, is 1,667,375.

Uncertainty

High Good animal data demonstrating adverse effects of various particulates, limited epidemiology data (i.e., particulates from diesel engines), at risk populations identified.

Assumptions

1. Exposure to particulate matter and associated carcinogenic compounds contribute to the cancer incidence in Region 6.

2. Subpopulations in areas that violate the PM,,, standard are exposed to particulate matter concentrations which put them at risk of experiencing adverse health effects.

3. Only respirable particulates which are less than 10 microns in size (PM,,,) are responsible for the adverse effects from particulate matter pollutants.

HAZARDOUS / TOXIC AIR POLLUTANTS
Combined Risk Category Ranking: 2

Problem Area No. 18

Hazardous/Toxic Air Pollutants

Substances Reviewed

Arsenic	Ethylbenzene
Asbestos	Ethylene dibromide
Benzene	Ethylene dichloride
1,3 Butadiene	Formaldehyde
Cadmium	Gasoline Vapors
Chloroform	Perchloroethylene
Carbon Tetrachloride	Products of Incomplete Combustion
Chlorobenzene	Styrene / o-Xylene
Chloroprene	Tetrachloroethylene
Chromium	Toluene
p-Dichlorobenzene	1,1,1 Trichloroethylene
Dioxins	Vinylidene Chloride
1,2 Dichloropropane	m,p-Xylene

Comments

Cancer Risk: The estimated risk of additional cancer cases caused by air toxics ranged between 257 and 505 for the substances listed above. The analysis involved extrapolation of national data and risk values, review of Regional monitoring information, and use of TRI data reports. These chemicals are only a small fraction of the 189 chemicals listed in the Clean Air Act (CAA) as air toxics and for which cancer risk information is available.

Non-Cancer Risk: Summation of hazard indices (HI) for several Region 6 "urban" counties produce HI values > 1. These populations (8,263,374 people) and most other urban areas can be considered as "at risk" to adverse health affects caused by air toxics. Again, this risk assessment was conducted using limited data sources for approximately 20 (of the 189 CAA) air toxics.

For these reasons, air toxics rank relatively high in both cancer and non-cancer health evaluations (risk category 2).

Toxic Release Inventory (TRI) 1988 release data ranks Region 6 as number 3 in toxic chemical stack and fugitive releases to air. The Region's industries, particularly the chemical, petrochemical, and petroleum refining facilities contribute significantly (16%) to the nations total air toxics emissions. However, stack and fugitive emissions contribute only approximately 25% of the total air toxics. Mobile source emissions account for 55% of air

toxics emissions and Region 6 accounts for approximately 13% of the total U.S. vehicle miles traveled (Texas ranks second only to California).

This problem area also includes industrial releases of CFCs and other stratospheric ozone depleting chemicals (halogenated hydrocarbons and nitrogen oxides) as well as global warming Contributing chemicals from industrial, residential, and mobile sources. In addition, many of the organic air toxics are considered ozone precursors and make a significant contribution to that problem area. To date, air toxics monitoring has been limited mostly to sites in urban areas or near facilities. To accurately determine the extent of this problem and measurement of public exposure, much more monitoring and development of monitoring techniques is needed. Air toxic releases in our Region contribute significantly to Regional health concerns as well as global and international problem areas. For more detailed information on TRI air emissions figures by state and county, mileage figures per vehicle type and state, and other air toxics information refer to RCRP Program Report 18A in Appendix D.

Uncertainty

High Good animal data, some worker exposure epidemiology data, lacking in ambient exposure information, reliance upon TRI data raises the uncertainty.

Assumptions

1. Hazard Indices can be added to obtain a cumulative evaluation of non-cancer risk.

2. When areas have similar industries, chemical emissions, and total amounts of releases to air it is appropriate to assume similar monitoring levels.

3. Risks from Region 6 air toxics emissions are proportional to those reported from national studies.

4. Regional monitoring data is sufficient to characterize the cities and counties studied.

5. Synergistic and antagonistic effects of the combined air toxics on their adverse health effects have not been studied, therefore, they were not considered in this problem area.

INDOOR AIR POLLUTANTS OTHER THAN RADON
Combined Risk Category Ranking: 1

Problem Area No. 19

Indoor Air

Substances Reviewed

Formaldehyde	Trichloroethylene
Benzene	Tetrachloroethylene
Chloroform	Chlordane
Carbon Tetrachloride	Heptachlor
1,2-Dichloroethane	Chemicals in Cigarette Smoke

Comments

Cancer Risk: The estimated annual cancer incidence from exposure to the 9 chemicals reviewed is 1,475 (0.005% of Region 6 population).

Non-Cancer Risk: It is estimated that exposure to indoor air causes discomfort and mild illness, including eye irritation, dry throat, headache, fatigue, dizziness, sinus congestion, skin irritation, shortness of breath, nausea, and nasal irritation. An estimated 210,000 to 585,000 persons in Region 6 are affected by one more of these symptoms.

Region 6 has a wide range of indoor air microenvironments which have not been characterized in source terms. The cancer risk analysis was based primarily on data from an EPA report to Congress. The non-cancer risk analysis was based on data provided in an EPA study entitled Indoor Air Quality Health Risk Assessment for Region 6. The analysis represented a very qualitative assessment of the health risk attributable to indoor air the Region.

Despite the acknowledged uncertainties and difficulties in indoor air risk evaluations, this problem area is ranked as a high concern (Risk Category 1) because of known exposures and adequate toxicological data for specific pollutants.

Uncertainty

Moderate	Good animal and some epidemiology data for the individual chemicals listed, limited exposure data, limited correlation between disease and specific noncancer pollutants.

Assumptions

1. The combined health risks posed by indoor air is difficult to determine (most indoor environments emit many pollutants, indoor environments vary greatly as do toxicants, many sensitive subpopulations are exposed).

2. Region 6 indoor air environments are similar to those nationally.

3. The entire Region 6 population is exposed to indoor air (to similar pollutants and concentrations).

RADON
Combined Risk Category Ranking: 1

Problem Area No. 20

Indoor Radon

Substances Reviewed

Radon

Comments

Cancer Risk: The estimated number of annual lung cancer deaths in Region 6 due to exposure to indoor radon is estimated to be 868 to 4459 with a median value of 2230.

Non-Cancer Risk: Non-cancer risk was not evaluated, however extrapolating from national estimates (Unfinished Business) yields 20 or fewer cases per year of serious mutagenic and teratogenic effects.

Radon is a naturally occurring, ubiquitous radioactive gas which the entire Region 6 population is exposed (28.5 million people). Radon decays to other radioactive elements, is deposited in the lungs when inhaled where it may cause lung cancer. Both epidemiological (human studies) and laboratory tests in animals have shown that exposure to radon and its decay products causes lung cancer. Therefore, scientific uncertainty is lowered and confidence in the unit risk calculations are high. Confidence in regional radon levels is moderate at best. The exposure numbers used are best estimates and not upper bound estimates. For the above reasons, the risk to the population of Region 6 due to exposure to indoor radon was ranked high (Risk Category 1).

Uncertainty

Low Good animal and epidemiology data, increasing evidence for indoor ambient exposures causing or contributing to lung cancer, Regional monitoring data being gathered.

Assumptions

1. Region 6 indoor radon environments are similar to those nationally.

2. All residents in Region 6 are exposed to some level of radon.

3. Health effects from radon exposure are exclusively via the air pathway.

RADIATION OTHER THAN RADON
Combined Risk Category Ranking: 2

Problem Area No. 21

Ionizing Radiation
Non-ionizing Radiation

Substances Reviewed

Ionizing Radiation	(natural background, occupational exposures, medical exposures and man made & technologically enhanced sources)
Non-ionizing Radiation	(electric power fields, microwaves, radio-waves and ultraviolet light)

Comments

Cancer Risk: From ionizing radiation in Region 6, 1028 fatal cancers due to natural background, 4 from occupational exposures, 4 from medical exposures, and 17 from man made/technologically enhanced sources. Approximately an equal number of non-fatal cancers occur in each of the aforementioned categories. Ionizing radiation is known to cause genetic and teratogenic effects, but no attempt was made in this study, to quantify those effects. Most of these cancers, except for the manmade/technologically enhanced category, are not well suited for amelioration by EPA regulatory activities.

Cancers may also be caused by non-ionizing radiation but the risk levels are far less certain than those from ionizing radiation. Based upon the results obtained by David Savitz, as many as 215 combined fatal and non-fatal cancers may occur in Region 6 due to exposures to electric power line electromagnetic fields.

Exposures to both ionizing and non-ionizing radiation are ubiquitous in our society. Ionizing radiation strips electrons from atoms and molecules which are exposed, sometimes breaking chemical bonds in critical biological and genetic material, causing carcinogenic, mutagenic and teratogenic effects which can be fatal or serious. .

Non-ionizing radiation exposures are suspected of causing a range of human health and behavioral effects, including fatal cancers, other biological changes, and circadian rhythm dysfunctions. Such effects cannot be confirmed or reliably quantified at the present time.

Uncertainty

Low	for ionizing radiation, known to cause genetic and teratogenic effects
High	for non-ionizing radiation

Assumptions

For ionizing radiation:

1. Cancer risk at low doses and dose rates is proportional to that at high doses and dose rates.

2. No threshold dose or dose rate exists in the risk vs. dose relationship.

For non-ionizing radiation:

1. Estimate of cancer induction by David Savitz, NY State Power Lines Project Study (1987) are correct.

2. Adult cancer induction effect is the same as for child cancer induction, estimated by Savitz (# 1 above).

STRATOSPHERIC OZONE DEPLETION
Combined Risk Category Ranking: 1

Problem Area No. 23

Stratospheric Ozone Depletion

Substance Reviewed

Ozone depleting chemicals: Chlorocarbons, Halocarbons, Nitrogen Oxides

Comments

Cancer Risk: Ozone depleting chemicals will exist in the atmosphere from decades to over one-hundred years. The cancer risk is therefore projected to the year 2075 (affected individuals are those alive in 1988 and born before 2075). Annual estimates of cancer cases and associated mortalities for Region 6 are: 1,167 melanoma skin and cancer cases, 232,772 non-melanoma if no CFC controls are implemented (4,609 and 276 mortalities per year respectively). If controls such as the Montreal Protocol are strictly observed, the annual incidence numbers are estimated to be 105 melanoma and 12,506 non-melanoma skin cancer cases (25 and 201 mortalities per year respectively).

Although fair skinned Region 6 residents are most at risk from increased exposure to UVB radiation, all residents can potentially suffer the harmful effects. This is because immune system suppression can also occur which reduces the body's ability to defend against tumor development.

Non-Cancer Risk: In addition to cancers, eye disorders, cataracts, and immune system depression can be caused by exposure to UV-B radiation. Estimates for Region 6 annual incidence of UV induced cataracts to the year 2075 is 28,626 cases if no CFC controls are implemented and 2,544 if Montreal Protocol level controls are strictly observed.

Stratospheric Ozone Depletion, like Global Warming, was very different from the other problem areas Region 6 had to evaluate. Different in that the human health impacts are likely to occur in the future. The Comparative Risk workgroups believed that stratospheric ozone depletion should be addressed for several unique reasons: 1) ozone depleting chemicals are also global warming gases, 2) the Region's emissions of CFCs and nitrous oxides through industrial and agricultural activities is significant, 3) the total Region 6 area would be affected, 4) there is convincing evidence that CFCs do adversely affect upper atmospheric ozone, 5) chemical releases occurring today will be the potential cause of the future adverse health and ecological effects, and 6) the belief that inactivity would exacerbate ozone depletion and potentially cause devastating and irreversible ecological, human health, and welfare effects in the Region and world wide.

Uncertainty

High Although good animal data exists for the affects of UV-B radiation and the at risk populations are well defined, the adverse effects from stratospheric ozone depletion can not be statistically demonstrated at this time; the potential impacts are none the less extremely important and must be aggressively addressed.

Assumptions

1. Predictions of future stratospheric ozone degradation are correct.

2. Future estimates of ozone depleting chemical emissions are accurate.

3. Extrapolation to 2075 (85 years) is appropriate for assessments of skin cancers, eye disorders, and immunosuppression end points.

4. Fair skinned residents of Region 6 are considered an "at risk" population and will be similarly affected by increased UV-B exposure.